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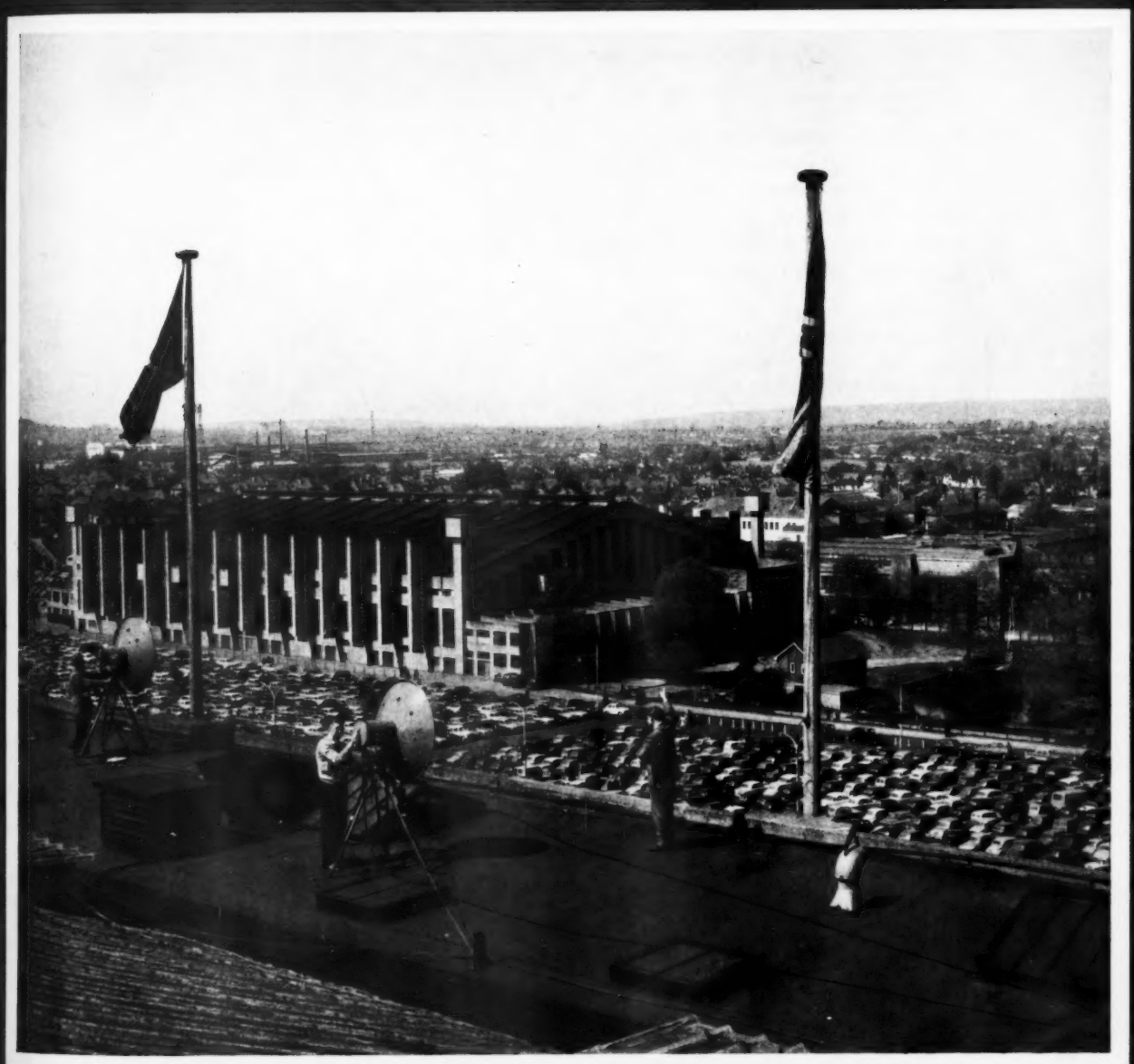

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JOURNAL OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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MICROWAVE LINKS

MICROWAVE links are becoming more and more important for telephone and television services. This month's cover illustration shows microwave equipment, operating at a frequency of 7207·5 Mc/s, on top of Wembley Stadium during an outside television broadcast.

The recently announced plans of the British Post Office for a 507 ft tower for microwave links are mentioned on p. 192, while a similar tower at Stuttgart, Germany, is the subject of Mr. J. F. Goodger's letter on p. 156. An article by Mr. W. J. Bray on p. 173 discusses international microwave radio-relay systems operating at frequencies above 1000 Mc/s. Mr. T. C. Macnamara and Mr. B. Marsden have an article on television-programme presentation on p. 145

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.
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JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 VOLUME 7 NUMBER 75 MARCH 1961

PHYSICISTS AND THE INSTITUTION

THE subject of electrical engineering had its origins in science; and its progress has been continually stimulated, and frequently revitalized, by scientific discovery, notably by new discovery in physics.

Its history may be said to have begun with the publication in 1600 by William Gilbert of Colchester, of his famous book 'De magnete' on magnetism and electricity, followed in 1675 by the first book devoted entirely to electricity, by Robert Boyle. These beginnings were clarified and extended by physicists such as Volta (1745–1827), Ampère (1775–1836), Oersted (1777–1851) and Ohm (1787–1854), to mention only a few.

To Michael Faraday, however, goes the great distinction, through his discovery in 1831 of the principle of electromagnetic induction, of initiating the many practical applications of electricity which are now our common heritage. Following his publication of this principle, Faraday turned his attention mainly to other matters and left its exploitation to his contemporaries. There was no lack of inventors, and from 1832 onwards a steady stream of proposals were made for electromagnetic machines of various designs. Even so the development of the electric generator did not begin to take industrial form until the 1870s, and was preceded in this respect by that of land and submarine telegraphy under the stimulation in this country of Charles Wheatstone and Lord Kelvin, both professors of physics. It was, therefore, entirely appropriate that the title of our Institution, when founded in 1871, should be the Society of Telegraph Engineers.

Since that date the progress of electrical engineering has been fantastic. Each step forward from new scientific discovery or technical invention has fed back new electrical tools to aid further scientific investigation, and the continuous interplay between the science and technology of our subject has been of profound benefit to both. But, whereas prior to the late war the physicist conducted his researches mainly in the universities, he has now become a vital staff member of the electrical industry, and not only within its research departments; and he is being joined there in increasing numbers by chemists, metallurgists and mathematicians. In combination with electrical engineers they compose the teams whose co-operative activity is essential nowadays to the pursuit of new developments. So much so that within a few years of graduation it is often difficult to observe, nor is it of great interest to know, from which particular undergraduate discipline they have individually emerged.

Many physicists and some mathematicians who have identified themselves with electrical engineering work, notably on the electronics and telecommunication sides, are members of The Institution, while others, who are not, have contributed valuable papers to the *Proceedings* or have participated in conferences and conventions which The Institution has organized. The participation of more of these men—and there are some women—in the activities of The Institution is indeed essential if these activities are adequately to reflect the kinds of electrical engineering progress to which they are making a vital contribution in the research or development laboratory or the design office. Clearly this will be achieved only if more of them are brought into the corporate body of The Institution through membership of it.

The attainment of this objective has undoubtedly been hindered in two ways. First, the granting of complete exemption from the examination requirements for Graduate membership was limited to candidates holding first-class honours in physics, although this limitation did not apply to candidates for election to Associate Membership, for which physics degrees were acceptable on a much wider basis. Secondly, the impression had been created that election to Associate Membership is conditional on the completion of a formal course of graduate training analogous to graduate apprenticeship.

The first of these difficulties has been removed by the decision to admit to Graduate membership those holding qualifications in physics, acceptable previously only at the Associate Member level. Thus the recently revised Examination Regulations recognize fully that a course leading to a physics degree can be an appropriate educational discipline in preparation for a career in electrical engineering. The new Regulations now provide that:

1. An honours degree in physics which is approved for this purpose by the Council is accepted for complete exemption from The Institution's examination requirements
2. A pass or ordinary degree in physics which is approved for this purpose by the Council is accepted for exemption from the examination requirements when

in supplementation the candidate has passed either advanced electrical engineering or physical electronics in the Part III Examination

3. A degree in mathematics, or a general degree in mathematics and physics, which is approved for this purpose by the Council is accepted for partial exemption, the candidate being required to pass electrical engineering in Part II, and the whole of Part III, of the Institution Examination.

An undergraduate who is reading for one of the above degrees may be admitted to Student membership if he intends to satisfy the requirements for admission to the class of Graduates and in due time to seek Corporate membership.

As it is expressed above, the second retarding factor is based on a misunderstanding which it is hoped the following statement will remove. It is of course correct that the Council of The Institution have long held the view that for the adequate preparation of professional engineers, education at a university or college requires to be supplemented by a further process, which they refer to as training, conducted in the environment of engineering practice. The objectives of this process of training are broadly to ensure:

(a) A sound knowledge of the properties, uses, limitations, and methods of handling of the conducting, insulating, magnetic and structural materials used in the construction of electrical apparatus and equipment

(b) An appreciation of the nature and interrelationships of the main functional aspects—research, development, design, manufacture, sales, installation and operation—of electrical engineering activity, of the contributions which need to be made to them by the professional, technician, craft and operative categories of people involved, and of the associated problems of organization and management

(c) An acquaintance with the various facets of a selected specialist field, normally in relation to a particular type of product, and of related fields on which the practice in it is dependent

(d) An understanding of the reasons, administrative and economic as well as scientific and technical, for present practices, and an enthusiasm to search for the directions in which improvements might more profitably be pursued.

The normal method by which electrical engineering graduates acquire this training is by graduate apprenticeship of two years' duration, following which, for election to Associate Membership, they are required to occupy a post of adequate responsibility in electrical engineering for a minimum period of two years.

Where, in the past, this training procedure has not been followed, and the graduate, whether he be an electrical engineer or a physicist, has entered directly into staff employment, election to Associate Membership has required four to six years, not two, of responsible employment. Direct entry into staff employment has not, therefore, as some have apparently thought, excluded Graduate members from transfer to Associate Membership, though it has delayed it.

The recently introduced Training Regulations have modified the situation in a way which will be of particular benefit to physicists. In appropriate cases the Council will now accept, in lieu of formal training, work carried out in a staff appointment under the supervision of a Corporate member provided that they are satisfied with the character of the work and with the range of basic experience it has afforded. In order that this may be assessed, it will be necessary for the Corporate member to submit a certified statement on these questions on the candidate's behalf. If a part, or the whole, of the work cannot be accepted as having afforded good training, it may be treated as 'additional experience', and as such will compensate for a deficiency in training on the basis that two years of 'additional experience' will compensate for one year's deficiency in training.

It is hoped that these changes in the Examination Regulations as applied to physicists and mathematicians, and the provisions of the Training Regulations in respect of training in staff employment, will encourage many more of the graduates in these subjects who are now making their careers in the electrical engineering field, whether it be on the telecommunication, electronics or power side, to seek membership of The Institution and to participate in its varied and expanding activities.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY REVISE STRUCTURE

THE U.K.A.E.A. will effect changes in their organization as from the 1st April 1961. In so doing, they will be following the recommendations of the Select Committee, regarding the Industrial Group of the U.K.A.E.A., included in the Committee's report dated July 1959, which advised that certain aspects of the Authority's organization be reviewed after a reasonable period.

The Authority have decided on changes, including the creation of a new Group, calculated to improve efficiency and co-ordination.

The designing and developing of nuclear reactors will be concentrated to the greatest possible extent in one Group, which will control the major development facilities required. For this purpose, the structure of the Development and Engineering Group will be modified and its name changed to the Reactor Group, which will be responsible for the design and development of reactors and for relations in this field with British and foreign industry.

The Winfrith Research Establishment, which has responsibilities in the same field, will be transferred from the Research Group to the Reactor Group. A new Engineering Group will be formed, which will be responsible for the design and construction of plant, works and buildings and for the design and inspection of fuel elements for production purposes.

ACCURACY IN A.C. MEASUREMENTS

621.317.3:53.088

This article discusses the accuracy with which alternating-current instruments can be compared one with another, and the accuracy with which their values can be related to the fundamental quantities of length, mass and time. These are given for various types of instrument in various conditions of use. The authors are at the National Physical Laboratory.

The whole topic of precision measurement was examined by the Measurement and Control Section of The Institution at a meeting on the 10th January 1961 *(see p. 195).*

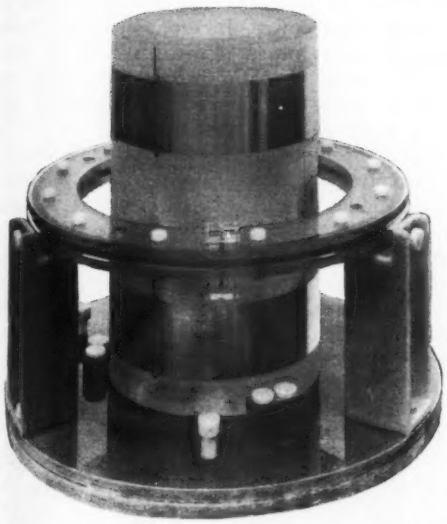
G. H. RAYNER, B.A., ASSOCIATE MEMBER, and
A. FELTON, B.SC.(ENG.), MEMBER

THE accuracy that can be achieved in a measurement may be considered as depending on two factors: the accuracy with which the value of the standard is known, and the precision that can be attained in the measurement or series of measurements by which the instrument under investigation is related to the standard. This article deals principally with the first of these factors, although the two are not as a rule independent.

System of units

The system of electrical units is not an arbitrary one but is derived from the units of length, mass and time in accordance with certain laws of electromagnetism. The electrical units usually derived first are those of resistance (or impedance) and current.

These fundamental derivations of the electrical units depend on apparatus, such as a mutual inductor or current balance, which can be used with precision in an electrical circuit and on which the required mechanical measurements can also be made with precision; these two requirements are partly antagonistic, and the accuracy of the fundamental determinations of the units is considerably lower than can be achieved in purely electrical or purely mechanical measurements.



1 *New N.P.L. primary standard of mutual inductance*

The uncertainties of most of the fundamental determinations are between 10 and 20 parts in 10^6, the resistance determination generally being the more accurate.

A new primary standard of mutual inductance at the National Physical Laboratory is shown in Fig. 1.

Material standards

The material standards which maintain the electrical units are standard 1 ohm resistors and saturated Weston cells. The standard reference groups of these maintain the units constant over a decade within about 2 parts in 10^6 for both resistance and voltage. Comparisons of the standards held by the principal national laboratories show a relative constancy of this order, for the most part, but it may be noted that there are small constant differences (up to several parts in 10^6) between the units as maintained in various countries.

The practical system of electrical measurements is built up from the basic reference standards. The accuracy attainable depends greatly on the quantity being measured—the more remote this is from the basic standards, the lower the accuracy; it also depends on the magnitude of the quantity, but the variation on this account is not so great, and with care it is possible in many comparisons to come near to the statistical limit which considerations of sensitivity, reproducibility, etc. would suggest.

Resistors

The most precise resistors are suitable for d.c. measurements only and customarily have values which are an integral power of ten. Their use as a.c. standards is precluded by eddy-current effects in the metal cases and the resistance wire itself and, with those of high value, by the large shunt capacitance and dielectric loss. Resistors for alternating current should be constructed to minimize these effects, and well designed fixed or adjustable ones have no significant change (<1 part in 10^4) up to 10 kc/s for values in the range 1–10^4 ohms.

The a.c. comparison of resistances presents little difficulty, and a sensitivity of 1 part in 10^4 can be obtained on ratios as large as 1000 : 1.

Resistors of less than 10 ohms which are to be used as time-constant or phase-angle standards should have both current and voltage terminals, as the residual series inductance is made definite, and stray mutual inductance is much reduced, thereby. Suitable networks, such as a double bridge, are required for their comparison.

For resistors of high value (above 1000 ohms), the uncertainty in the shunt capacitance may be significant unless there is an independent screen and the circuit allows the admittances associated with it to be excluded from the measurement. The time-constants of resistors can be compared to within 1 or 2×10^{-9} H/ohm at audio frequencies for the range 0·01 ohm to about 10^5 ohms, and somewhat less accurately at power frequency.

Capacitors and inductors

Capacitance can be derived from the primary standard of mutual inductance with an error that does not exceed 10 parts in 10^6, and, allowing for possible errors in the primary standard, is known absolutely to 20 parts in 10^6.

Capacitors, whether two- or three-terminal ones, can be made strictly additive in value by appropriate screening; it is possible, therefore, to obtain an accurately consistent scale of capacitance values over a wide range. The instability, even of good capacitors, is the main limitation in precise capacitance comparisons, as a discrimination of 1 part in 10^6 can be obtained except on small values or at low frequencies. The stability of capacitors is unpredictable: although some standard mica capacitors may show variations within a range of only 30 parts in 10^6 over several years, others which are of similar construction may show much larger changes.

The smaller-value capacitors are usually less stable than the larger ones. Air capacitors are more easily affected by mechanical shock; a good-quality capacitor treated carefully is likely to remain constant within 1 or 2 parts in 10^4 over several years.

Inductance is obtained from the primary-standard mutual inductor without the introduction of any other electrical quantity and, in consequence, can be determined more accurately than capacitance; however, there are greater practical difficulties than with capacitance. The resistance of self-inductors causes their loss tangent $(1/Q)$ to be considerably larger than for a capacitor. In addition, the magnetic field of an inductor may induce e.m.f.s in other parts of a circuit.

Self-inductance is definite only for a complete circuit, and low-value inductors may be uncertain by 0·01 or 0·02 μH because of the gap between the terminals, unless the circuit is completed in a defined and reproducible way. The effective inductance of large inductors is increased at high frequencies by the self-capacitance, and sometimes the indefiniteness of this will add to the uncertainty of the effective inductance. Self-inductors may be compared with one another with an error not worse than 1 part in 10^4 for values not differing too greatly and within the range 100 μH to 1H, provided that the Q-factors are not very dissimilar.

Mutual inductors of equal value can be compared readily, and because the mutual inductances of two coils to a common third coil are strictly additive, a precise scale of mutual inductance can be obtained by a simple building-up technique. At power frequencies, the phase-defect or impurity of a mutual inductor is small, provided that there are no large metallic parts in which eddy-currents are induced. At audio frequencies, capacitances between the windings alter the effective mutual inductance, and stray capacitances may make it uncertain; the capacitances increase the impurity as well. For a 10mH mutual inductor, the effective inductance is likely to increase by a few parts in 10^4 at 1 kc/s.

The constancy of inductors, which is dependent on the dimensional stability of the coil and former, is on the whole better than that of capacitors, and variations found between different instruments are somewhat less.

Voltage and current measurements

In practice, the electrical measurements that are of most importance to electrical engineers are those of current, voltage and power. In direct-current circuits, these quantities can be measured with an accuracy which is only slightly worse than the precision to which the basic electrical units—the ampere and the ohm—are known, since quantities greater or smaller than the unit quantity can be determined by build-up techniques which, since they involve only comparisons of nearly equal quantities, introduce uncertainties which can be kept down to 1 part in 10^6 or less.

On alternating current, however, there are no corresponding fundamental standards, and it is necessary to introduce the concept of a 'transfer standard', i.e. an instrument which has the same, or very nearly the same, response on alternating as on direct current.

Transfer instruments

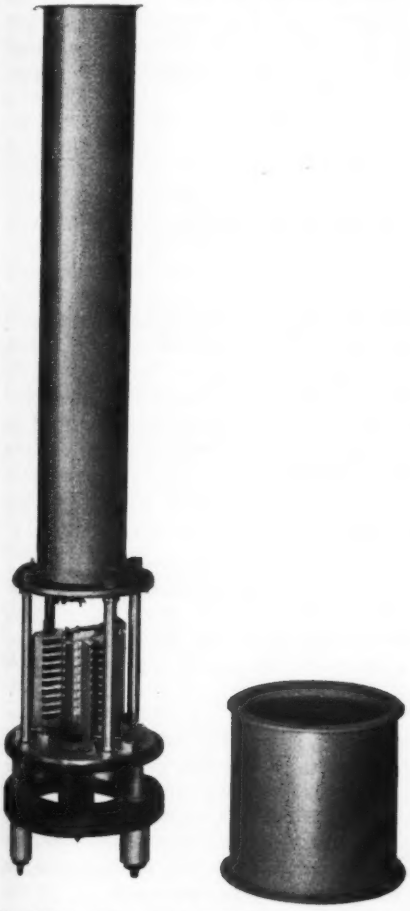
Since, in the enormous majority of applications, it is the r.m.s. value of an a.c. quantity that is of interest, the transfer instruments that are used are 'square law' instruments depending on the force between conductors carrying current (electrodynamometers), the force between conductors at different potentials (electrostatic voltmeters), or the heating effects of an electric current (thermal instruments).

The electrodynamometer is a satisfactory instrument at low frequencies, and with careful design its transfer error is no greater than its sensitivity, i.e. about 5 parts in 10^5. At frequencies exceeding 1 kc/s, however, the inductances and capacitances associated with its measuring circuits introduce increasing errors which are difficult to allow for.

The electrostatic voltmeter

The electrostatic voltmeter avoids some of the spurious effects of inductance and capacitance, and is the instrument that has been the transfer standard at the N.P.L. for half a century. In a modification, due to E. H. Rayner, of the original Kelvin multicellular voltmeter, the optimum sensitivity is a few parts in 10^5 at 100 volts. The fixed and moving electrodes are of aluminium alloy, and the partially conducting films which inevitably form on their surfaces introduce a transfer error of up to 15 parts in 10^5.

This need not, however, lead to any error exceeding a few parts in 10^5 in the measurement of alternating voltages, because the transfer error of a particular voltmeter can be determined to this precision by comparison with a specially constructed voltmeter having electrodes of a noble metal, such as platinum, which is free from the partially conducting films that form on aluminium.



2 *N.P.L. electrostatic voltmeter with cover removed to show the elements*

In the result, an alternating voltage of about 100 volts can be determined with an uncertainty not greater than 1 part in 10^4 at any frequency from power frequency up to 100 kc/s. At higher frequencies, the voltage drop in the suspension and the series inductance of the instrument become increasingly important, and for radio frequencies the thermal instrument is more satisfactory.

Fig. 2 shows an N.P.L. voltmeter with cover removed.

Thermal instruments

Thermal instruments, consisting either of a thermocouple attached to a heater or a temperature-sensitive resistor (such as a thermistor), can be used to measure current from power frequencies to the lower radio frequencies with a transfer error not exceeding 1 part in 10^4.

Taking into account all their known errors, the electrostatic and thermal instruments agree within 5 parts in 10^5 up to a frequency of 50 kc/s. Above this, the discrepancies increase, but this is of no practical consequence because there appears to be no demand for high accuracy above the audio-frequency range.

Extension of basic ranges

The basic ranges of the transfer instruments can be extended upwards by means of series resistances, voltage dividers, current shunts or transformers, as appropriate; and downwards by means of transformers or electronic amplifiers. Similarly, the function of an instrument can be changed; for example, a thermal convertor, which is essentially a current-measuring instrument, can be used to measure voltage by the addition of series resistance, or an electrostatic voltmeter can be made to indicate current by connecting it across a suitable shunt.

None of these expedients need lead to any appreciable error, for the values of resistors, even on alternating current, can be ascertained to an accuracy better than the sensitivity of the transfer device.

Measurement of power and energy

Probably the quantity most interesting to engineers is electrical power, since, in conjunction with the measurement of time, it leads to the evaluation of energy—a quantity of obvious economic importance.

On direct current, the accuracy of measurement is limited only by the uncertainty in the fundamental units, because power is then the arithmetic product of current and voltage. On alternating current, however, the accuracy is reduced on account of waveshape and phase difference between the current and voltage waves on any but purely resistive loads. In general, it is necessary to measure power by means of a wattmeter calibrated on a known load of zero or known phase angle.

Wattmeters

The three types of wattmeter available for accurate work are again the electrodynamometer, the electrostatic and the thermal. None can be considered superior to the

others in all circumstances, but each has advantages and disadvantages according to the conditions of use. It is sufficient to say here that the best accuracy obtainable in optimum conditions in the laboratory is within about 5 parts in 10^4. In the field or in extreme conditions of current; voltage or frequency, the accuracy is considerably worse.

Sources of supply for testing purposes

In all electrical measurements, except those of the bridge type, the accuracy attainable is conditioned by the steadiness of the supply.

On direct current this is no serious limitation, since battery supplies can usually be arranged that are steady within 1 part in 10^6 or better for the period of the observations.

On alternating current, however, conditions are very different; and until a decade ago, when motor-driven alternators were the only practicable source of current for testing purposes, the unsteadiness of supply was the chief limitation on accuracy. Today, stabilized electronic generators are available that have a harmonic content of less than 0·5% and are steady within a few parts in 10^5 for the few minutes that are necessary to take a series of observations.

Summary

The absolute values of inductance and capacitance can be obtained at best to an accuracy within about 10–20 parts in 10^6, while the calibration accuracy achieved for individual instruments is in general within between 30 and 100 parts in 10^6.

Voltage and current at frequencies up to 50 kc/s can be measured with an uncertainty of the order of 1 part in 10^4, while the accuracy of power and energy measurements in the same conditions is within about 5 parts in 10^4.

INSTITUTION COUNCIL MEETING ON THE 2nd FEBRUARY 1961

THE following summary of reports received and decisions reached by the Council of The Institution at their meeting on the 2nd February 1961 is issued on the authority of the President in a form approved by the Council. It will be understood that this report does not purport to be a complete account of the matters discussed at the meeting, as some items are to be the subject of further discussion by the Council.

Honours conferred on members

It was noted that, in addition to those recipients of New Year Honours reported at the January 1961 meeting of the Council (see February 1961 *Journal*, p. 127), Mr. F. B. Holt, MEMBER, was appointed a Member of the Order of the British Empire.

Membership

The Council gave final confirmation of the election of those candidates whose names had been published with the December 1960 *Journal*, to become effective from the 1st February 1961. Taking these into account, the total membership at that date was 47081.

Committee on Broadcasting

On the recommendation of the General Purposes Committee, the Council authorized the submission of a brief statement in response to an invitation to submit evidence to the Pilkington Committee on Broadcasting.

1962 Summer Meeting

Confirmation was given of arrangements being put in hand, on the authorization of the General Purposes Committee, for the 1962 Summer Meeting to be held in the Mersey and North Wales Centre from the 18th to 22nd June 1962.

Saaler bequest

The Council learned with appreciation of a bequest by the late Mrs. Frances Redfern Saaler of £5000 to meet the cost of building a house on the Chesters Estate in commemoration of her late husband, Mr. J. W. Saaler, MEMBER. The terms of the bequest were accepted on the recommendation of the Court of Governors of the Benevolent Fund and of the General Purposes Committee.

Deputy Oversea Representative for the Middle East

The Council approved the appointment of Mr. E. R. J. Pugsley, ASSOCIATE MEMBER, as Deputy Oversea Representative of the Council for the Middle East during the period of Mr. H. D. Furber's absence from Baghdad on summer leave.

Institution Library

Dr. R. L. Smith-Rose, on behalf of the Chairman of the Papers Committee, introduced the report on the Library of The Institution for 1960. This briefly reviewed the work of the Library during the period 1st January to 31st December 1960, and its main features were reference to the new accommodation and statistics showing the increased use made of the Reference and Lending Libraries.

Sub-Centre Chairmen at Council meetings

On the recommendation of the Local Centres Committee, the Council agreed that Chairmen of Sub-Centres attending Council meetings as observers should be permitted to raise points of general interest for discussion. Although it might not always be possible to find time to debate these on the spot, they could nevertheless be included in the agenda for a forthcoming meeting. This arrangement was welcomed.

621.397:621.395.625.3:621.374.32

Engineering aspects of television-programme presentation in Britain

The method of obtaining revenue and the differences in programme formats and distribution needs are the main factors which differentiate the requirements of commercial and non-commercial television. This article discusses the importance of accurate timing, the technical aspects of master control and switching, and the applications of video-tape recording.

The article is based on the authors' lecture to the Electronics and Communications Section at Savoy Place on the 24th April 1959 entitled 'Engineering aspects of commercial television programme presentation' (see August 1959 Journal, p. 491). Mr. Marsden presented the lecture also at a meeting of the East Anglian Sub-Centre at Norwich on the 6th December 1960.

The authors are with Associated Television Ltd.

T. C. MACNAMARA and **B. MARSDEN,**
ASSOCIATE MEMBERS

THE biggest single factor which determines the difference between the requirements of commercial and of non-commercial television-broadcasting organizations is the method of obtaining revenue. In a commercial organization, revenue is closely linked to the programme presentation, whereas in a licence-maintained establishment the relationship is indirect and comparatively remote. Another fundamental factor arises from differences in programme formats and distribution needs.

A non-commercial body operates, in general, by producing a single programme at its main programming centre and distributing it to satellite stations throughout the country. On occasions the regional stations may break away from the network feed and insert local material, but the main programme output in any one region is generally that programme originated at the centralized distribution point. In these circumstances, timing problems are of far less importance than in a commercial undertaking, since an under-run of programme can be accommodated by arranging for the following programme to start early, and, from the viewer's point of view, continuity of programming is maintained.

In a commercial operation, however, the output of a station consists of locally generated programmes mixed with programmes produced by contractors in all parts of the country, together with news from a centralized source at certain specified times.

Timing

The process of collating all the available signals is highly complex and calls for extremely accurate timing throughout. Unless each individual station runs to an accurate time schedule, the complicated programme pattern will not fit together without overlapping, nor will the 'commercials' be broadcast within the time segments allocated to them.

A programme broadcast in London may be simultaneously broadcast in Scotland, while a different programme originated and broadcast in Manchester is relayed to Wales, the two programmes being followed by a programme originated in Birmingham and broadcast by all the contractors in Britain. This illustrates the need for accurate and precise time-keeping and switching of the sound and vision circuits at an exact predetermined time.

The most essential need of a broadcasting system is an exact means of indicating a common time at all the points in the system. A great deal of thought was given to this problem, an additional factor being that possible variations in mains-supply frequency could affect the running time of programmes from film machines. It was finally decided that the Post Office TIM standard should be adopted as a reference, and that contractors would adopt whatever system they felt was applicable to their region, referring at all times to TIM for correction purposes.

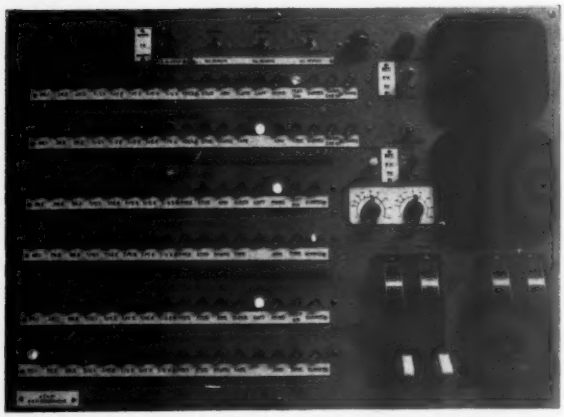
Clocks of various kinds are therefore used throughout the commercial-television operation, including valve and transistorized crystal standards with frequency dividers producing either one-second impulses or 50c/s sine waves, and pendulum master clocks operating half-minute and one-second stepping clocks. We feel that the sweep type of second hand, such as is obtained on a 50c/s synchronous clock, is infinitely preferable to the stepping clock for master-control-room use. For studio control rooms the stepping clock is equally acceptable.

The provision of accurate time on outside broadcasts has always been a problem. Clockwork time-pieces, even of the highest accuracy such as is found in ships' chronometers, cannot be relied on to give accurate time in outside-broadcast conditions without continual resetting of the clock. Several designs have been attempted, but the procedure now adopted is to feed TIM continuously down the engineering-control line which exists between the outside-broadcast unit and the master-control centre, the time signal being muted whenever the telephone circuit is in use for speech.

Time-keeping

Let us now consider some of the artifices adopted to achieve accurate time-keeping. During the course of a rehearsal, the studio manager is informed of the time-keeping, and is able to speed up or slow down the tempo

of a production. A display of clocks bearing the programme running time helps on occasions, and when teleprompters are used the operator can speed up or slow down the display of the script to maintain the artist's delivery to a predetermined schedule.



1 *Master-control-room switching panel for local and network control*

In film programmes recorded at 24 frames/sec, considerable embarrassment can be caused if they are run at 25 frames/sec. In a nominal one-hour programme this can represent an under-run of 2·4 min, necessitating the insertion of some form of padding. To overcome this difficulty, vidicon-telecine channels working on normal 25-frame/sec standards have been used, but with the film projected at the normal 24 frames/sec. A compensating signal is derived which is representative of the interference signals present, and this is used to cancel the flicker and application bars. Telecine machines are now available with optical chasing devices which permit non-synchronous film projection without the necessity for eliminating application bars etc.

Master-control rooms

The output from each programme contractor to his local transmitter consists of locally originated programmes and those coming from other contractors throughout the country. In between the programmes and in natural breaks within them, the commercials for the region in which the transmitter is located are inserted. A master-control room must therefore have comprehensive facilities to cater for the extensive programme distribution that takes place and the necessity for precise timing.

When a contractor is sending a programme to other regions, he must omit the commercials within, before and after the programme. This can be achieved by taking a parallel feed from the originating studio or by installing additional switching apparatus in the master-control room, alongside the equipment necessary for the local operation.

'Clean feeds' of programme only are necessary for several reasons, predominant among them being the need for a constant feed of synchronizing pulses from the originating studio to the recipient to enable contractors to 'slave', or genlock, their local equipment to improve presentation. Another reason is to avoid the possibility of part of the commercial from the originating contractor being radiated by the recipient before he has had time to mix from the network feed to his local commercial.

Network-switching facilities are found in the control rooms of most contractors, but a contractor feeding very few programmes to the rest of the network usually adopts selection on jackfields. Fig. 1 shows a typical master switching panel for local and network control.

Master-control rooms in commercial television are usually equipped with a sound mixer, a vision mixer and a master switching system, whose complexity depends on the amount of interchange of programmes between that station and the network. It is also necessary to provide elaborate intercommunication facilities between all parts of the local contractor's premises and other stations in the network.

It is usual to arrange that all the sound and vision signals entering the master-control area are available for selection on the sound- and vision-mixing panels and on the master switching panel, one input to the master panel being the output of the mixers. The output selected for feeding to the transmitter can therefore consist of an input signal directly selected on the master switching system, or the output of the vision mixer which can consist of any two other signals entering the control room. This system is much favoured among programme contractors, since the master switching panel acts as an emergency switch to the vision mixer in the event of breakdown.

Video-tape working

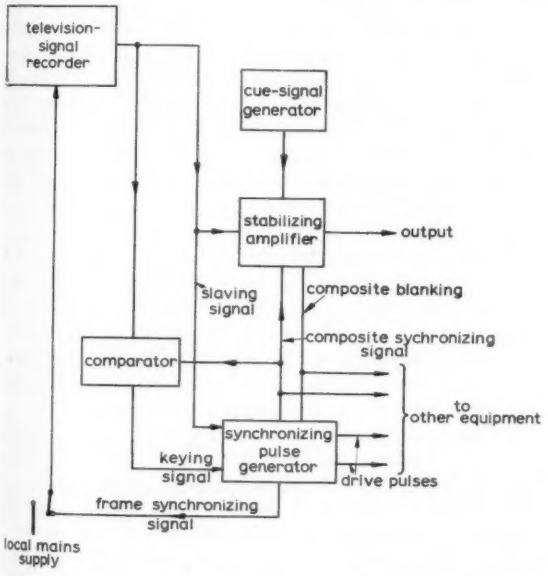
Commercial television relies for its income on advertising. Commercials range from 8 sec slides with spoken announcements to filmed or live commercials lasting up to three minutes. In order, therefore, to ensure a smooth presentation of all the changes of sound and vision in a commercial break, programme contractors have tended to adopt mixing techniques which necessitate the extensive use of 'slaving' and genlocking equipment for those signals originating beyond the master-control area. The reduction of lines between all the programme contractors to an economic minimum frequently results in a programme which is to be transmitted at, say, eight seconds past the hour not being available for more than eight seconds before the actual time of transmission.

For this reason, 'slaving' equipment has been developed which can perform the genlocking action automatically on the operation of one switch, the complete locking operation taking place in no more than a few seconds.

The advent of video-tape recording, however, complicated things; and, in view of the desirability of preserving a high standard of presentation, some effort has been made to devise methods of integrating pictures from video tape into programmes containing pictures generated by more conventional equipment.

A video-tape recorder, by virtue of its design, does not produce synchronizing signals until it has been running at speed for quite a few seconds. A further disadvantage with video-tape machines is that at standstill they do not emit any identification signal which can serve as a reassurance to recipients of the recorded programme that they are connected to the correct source.

One system that has been developed to permit the integration of video-taped material into the transmission is illustrated in Fig. 2. The video-tape machine feeds the outgoing line via a stabilizing amplifier. A synchronizing generator feeds composite synchronizing signals and blanking into the stabilizing amplifier. From the output of the stabilizing amplifier issues a constant train of synchronizing pulses, whether the video-tape machine be running or not. There can also be fed into the stabilizing amplifier a cue signal from a generator, that serves as an identification on the outgoing line. When



2 *Block diagram of equipment used to provide automatic 'slaving' of a station synchronizer with a video-tape recorder*

the video-tape machine is at rest, the video amplifier in the stabilizing amplifier is not contaminated by the noise normally generated by such a machine at rest.

The video-tape machine can be locked in its replay mode, either to the 50c/s power supply or to frame-trigger pulses derived from the composite waveform of the synchronizing generator. In one method, the replay

3 *General view of a video-tape installation*

machine is fed via a two-position switch from the frame-trigger pulses of the synchronizing generator, or a local mains reference.

When the replay button of the machine is pressed, it runs up to speed, locking itself to the synchronizing generator, so that when it reaches normal stable running speed the composite signal is very nearly coincident with the composite signal from the synchronizing generator. Between the output of the video-tape machine and the synchronizing generator, a comparator is introduced which samples the two wavetrains and, when the two signals are coincident, emits a keying signal which, fed into the synchronizing generator, causes the generator to 'slave' or lock to the signal issuing from the video-tape machine.

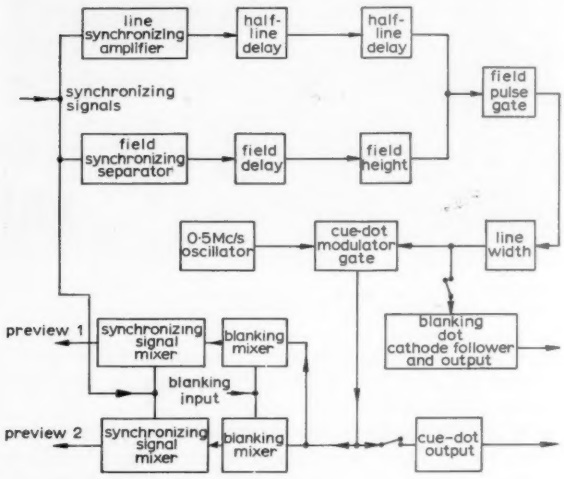
At the same instant as the synchronizing generator is 'slaved' to the video-tape machine, the tape-locking signal is changed over from the frame-trigger pulses of the synchronizing generator to the local mains. A suitable fixed phase-shifting device ensures that, when the synchronizing generator has 'slaved' to the output of the video-tape machine, the mains reference signal then selected by the video-tape machine for locking purposes is coincident in phase with the signal previously seen from the frame-triggering output of the synchronizing generator.

The actual disturbance on the outgoing train of synchronizing pulses is very small, and the four sets of synchronizing signals from the synchronizing generator can also be used for the operation of conventional television equipment.

Most video-tape machines can be modified to achieve a stable running speed in much less than five seconds. Allowing, therefore, a maximum of, say, three seconds

to perform all the 'slaving' functions just described, it is permissible with this system to use the standard five-second roll-cue common throughout the commercial-television network.

Thus we can look at the video-tape machine in much the same way as we have come to regard telecine machines. The disadvantage of the system is that only one video-tape machine can be integrated with the station output, since, in the actual conditions of replaying a tape, the tape machine is the master and the rest



4 *Block diagram of cue-dot generator*

of the equipment the slave. Operationally this is not a great demerit, but we look forward to systems of locking the video-tape machines to the rest of the station synchronizing equipment. Fig. 3 gives a general view of a video-tape installation.

Cueing

The efficient operation of the commercial-television network necessitates an enormous amount of detailed preplanning of programmes and commercial-break timing. Video cueing has been adopted as a ready means of passing information from the originating studio to the recipients of the programme. Video cueing involves the use of an electronic generator which punches a hole in the outgoing waveform of a studio and inserts a very obvious striped pattern, readily seen by recipients of the signal, regardless of the tone of the screen at that particular point.

This video pattern is placed in the top right-hand corner of the screen, and it is not normally seen by home viewers owing to the curvature of the picture mask. It is, however, seen in control rooms throughout the country. The method of operation is as follows:

When the originating producer realizes that he is approaching the time at which the commercial should be inserted, he switches on the cue generator (Fig. 4), which impresses the striped dot on the outgoing signal. He does this about one minute before the actual break, but the exact time is not critical. Operators throughout the country are alerted on seeing the cue dot, and stand by ready to re-insert the commercial. Exactly five seconds before the producer ends his programme contribution, he switches off the cue dot. The disappearance of the dot is the cue for telecine operators to run their machines; and, exactly five seconds after the disappearance of the dot, the master-control operators mix from the programme to the commercial.

This method of cueing permits a very smooth mix from the programme to the commercial and greatly improves the presentation. Similarly, cue dots are used at the end of programmes to indicate the precise time at which the producer will finish his programme, and commercials are smoothly inserted following the procedure used for the breaks within the programme.

The use of video cueing has been extended to solve one of the problems associated with video-tape recording. If a recording is to be mixed with live material, means must be provided of recording the appropriate cues. A cue dot placed in the upper left-hand corner is satisfactory for video-tape insertions in live programmes.

Advantages of video tape

In the United States, video-tape recorders have revolutionized the method of working, enabling programmes to be stored with negligible degradation to overcome the time-differential difficulties between the three time zones. The size of the United Kingdom does not present us with this problem, but there is a problem of comparable magnitude confronting certain of the programme contractors who have only a five-day, or a two-day, licence.

These contractors are faced with a heavy capital expenditure in providing and equipping studios and staff to meet the peak loads imposed on them during operating days. By using the video-tape process, they can record programmes at any time during the week, when their studios would otherwise be lying idle, and broadcast on the operating days quite satisfactorily.

Video-tape recording for inserts in live programmes has many advantages. Frequently, for example, a short insert, which has been prerecorded by the players themselves, is needed to cover a costume or make-up change to represent the passage of some years, or a change in the setting of the scene. We have described above a method of locking video-tape signals in other types of programme signal to enable such inserts to be introduced by wiping, mixing, superimposition, etc.

The inserts can be prepared during rehearsal and are immediately available for preview by the director and the cast. They exactly match the live production in picture quality and sound balance. This technique is now used extensively and, particularly in drama productions, has considerably increased the range of effects available to a producer.

Summary

Television broadcasting was an already established technique when the British commercial-television network was first set up. There was therefore an enormous fund of knowledge that could advantageously be used, but this was primarily applicable in the production sphere. Master-control techniques had to be evolved to meet the new requirements of commercial-television broadcasting as adopted in Britain, and this article gives a few illustrations of the problems met and the methods used in overcoming them.

Great Britain was the first country to use the spot method of television, i.e. a system in which the commercials are inserted separately and bear no relation to the programme. This requirement, plus the unique system of networking between programme contractors, necessitated the adoption of new techniques.

The introduction of video-tape recorders was welcomed by programme contractors, since, if used wisely, they permitted much better usage of staff and equipment. Their design, however, was such that many technical problems had to be overcome if programmes recorded on video tape were to be inserted with other material emanating from more-conventional television equipment. These problems have been overcome, but we look forward to further developments in equipment which will permit users to regard the output from a recorder as being similar to that from telecine machines etc. in the same area.

GAPS IN BRITISH TECHNOLOGICAL RESEARCH

This article embodies the views expressed by the General Purposes Committee and the Council of The Institution in considering what were the most significant gaps in present research work bearing on electrical science and engineering and their applications. These views were submitted on The Institution's behalf by Sir Willis Jackson, Past-President, to the British Advisory Council on Scientific Policy, who had requested the assistance of The Institution in this matter.

In November 1959 the Advisory Council on Scientific Policy were invited by the Minister for Science to make an authoritative review of the balance of Britain's scientific effort and, to help them in their task, the Advisory Council later sought the views of the professional institutions on the most important gaps in currently conducted research in their respective fields.

When this request came before the Council of The Institution, they readily accepted an offer by Sir Willis Jackson, the then President, to convey, through his personal contacts with the Advisory Council and its officers, the views which had been expressed by the General Purposes Committee and the Council in their discussions of the question which had been put to them. These observations found general expression in the 1959–60 Report of the Advisory Council on Scientific Policy, some excerpts from which were published in the November 1960 *Journal*, p. 644.

Stimulating new lines

Subsequently, the Department of Scientific and Industrial Research, acting at the request of the Minister, invited The Institution to take steps to ensure that the views expressed were brought to the attention of all those to whom they would be useful, particularly with the object of stimulating new lines of research at universities and technical colleges.

The invitation has been considered by the Research Committee of the Council, and at their request the following summary is published of the particular areas in which additional research appears desirable, in the hope that any members able to influence the shaping and conduct of research programmes will give special consideration to these topics.

In so doing, those who are responsible for researches in universities or colleges of technology may bear in mind the assistance which the D.S.I.R. are willing to give to promising and timely projects through their scheme of research grants, and also the help which The Institution, and particularly its Research Committee, and the D.S.I.R. can jointly offer, should some measure of co-ordination among the various projects which are put forward appear desirable.

The submissions to the Advisory Council ranged widely, but it will be seen that all the topics, listed in the summary set out below, have a bearing on the advancement of electrical science and engineering and their applications, and are thus of concern to The Institution and its members.

Building up research teams

Although there is a steadily rising activity in research and development in this country, there is evidence that Britain needs to put still more effort into the discovery of new facts and their technological application and commercial realization.

Many of the fields of research likely to be profitable

in the next few years demand a concerted effort by physicists, chemists, engineers and metallurgists. Such teams can and must be built up in industrial research establishments; and the universities must also take their part in this work. The universities can make a major contribution in fundamental studies, by the generation of new ideas, and by breeding research men with the right attitude to present-day technology.

The need is not so much to fill gaps in knowledge (although some gaps are listed by area below) as to build up research teams to study, more deeply and broadly, existing promising fields.

Materials

Study is wanted of the basic properties of materials of all kinds, notably the development and assessment of metals of extremely high purity and of materials capable of operating at temperatures of 2000°–3000° C. These would have a particular relevance to new possibilities of power generation by thermoelectric, thermionic and magnetohydrodynamic methods.

Metal forming

Fundamental examination is needed of the mechanics of metal forming, with the object of reducing the amount of machining to a minimum. In particular, the possibilities of combining such processes as forging, drawing, piercing, extrusion, etc. for forming complicated parts, and improving metal flow, should be investigated.

Work should be done on very high hydrostatic pressures in forming operations; explosive forming; vibration; and erosion.

Automatic control

We need a wider study of control theory, not only for the control system but for a better understanding of the machines to be controlled. It is not sufficient to superimpose recognized control systems on existing machines. We must design and develop the machine and its control as one if the successful application of fully automatic control is to be achieved.

Cybernetics

The application of physical and technological principles to the investigation of physiological, psychological, economic and related fields should be capable of yielding valuable results. A specialized aspect of this is the help being given by engineers to the orthopaedic surgeon in making artificial joints and bone structures (biomechanics). Noise is another important aspect.

Plastics engineering

The mechanical and other properties of plastics can be varied over a wide range by appropriate working, such as extrusion, calendering, injection moulding, orientation, etc. Much more research is needed on these processes and also on the measurement of the mechanical properties and on the formulation of assessment tests, with a view to enabling plastics to be used for stressed parts in machines and structures on a rational design basis. This will demand a deeper understanding of the interdependence of mechanical properties, chemical composition and physical structure.

Fracture mechanics

An attack is necessary on a broad front on the whole problem of fracture on a macroscopic scale in metals and non-metals. The objective should be on the one side to link up with the fundamental approach (e.g. by dislocation theory for metals) and on the other to develop notch-tough materials, particularly a *cheap*, weldable, tough structural steel, for use at low ambient temperatures.

Vibration engineering

Factors in the design and use of large engineering structures and machines under dynamic loading should be investigated. This field is important in ships, gantries, draglines, buildings, etc. It links up with fracture problems at low ambient temperatures, and with fatigue conditions.

Another aspect of vibration work that needs much more attention is noise generation and its suppression.

Low-temperature engineering

The possibilities of employing low temperature as a means of modifying and improving the mechanical, electrical and other properties of materials need wider examination. Many applications are possible in the fields of electronics, surface phenomena, and even fuel and power.

It is the hope of the Minister for Science, and of the Council of The Institution, that the matters set forth above will receive the special consideration of those of our members who are engaged in the planning and conduct of research and development work.

NEW V.H.F. STATIONS

Work is well advanced on the British Broadcasting Corporation's new v.h.f. sound-broadcasting stations at Sherriff's Mountain, Londonderry, and at Les Platons, Jersey.

The stations are being built on sites where television stations are already in operation, and these buildings have been extended to accommodate the additional equipment. The aerials for the v.h.f. sound programmes have been erected on the existing television masts.

With these new facilities, the B.B.C.'s v.h.f. sound service will be extended to 120000 more listeners in Northern Ireland and to listeners in all the Channel Islands.

It is hoped that the stations will begin working this summer.

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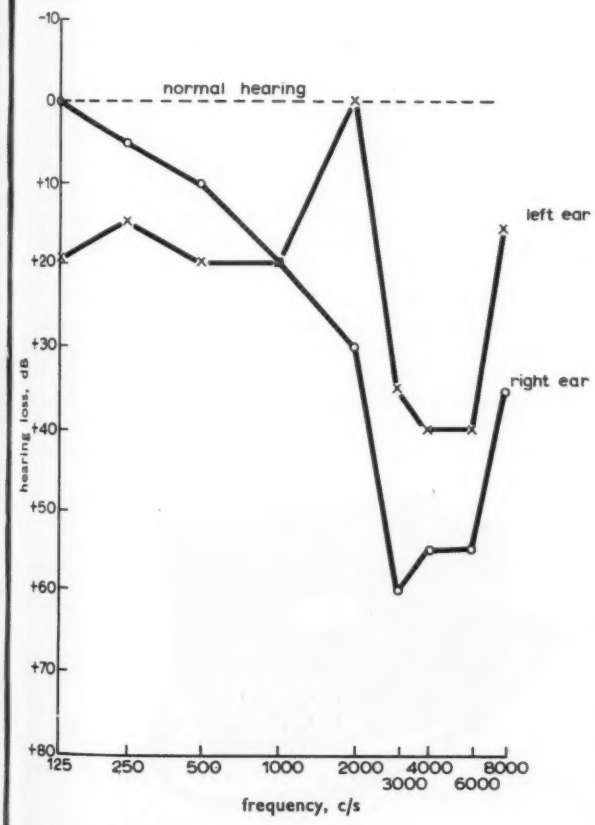
Industrial noise hazards and their prevention

High noise levels may hinder the efficient conduct of industrial operations and adversely affect the health of personnel. This article reviews these difficulties and indicates how noise measurement may be utilized to assess the extent of the problem and to indicate the approach to noise-control measures. The author is with the Occupational Hygiene Service.

D. E. HICKISH, PH.D., ASSOCIATE MEMBER

THE problem of noise in industry is not new, the literature containing references to the subject at least as early as 1802. The pattern and character of industry is, however, undergoing a period of great change, as economic trends demand that utilization of human effort be of the highest efficiency if industry is to survive.

An immediate result has been the widespread conversion to mechanical operation of procedures previously performed manually, and the ratio of machines to men is constantly rising. Attendant on this rise there is frequently a corresponding rise in the level of noise accompanying the process, and whereas the problem of noise was originally confined largely to a few heavy trades, such as boilermaking, it is now almost ubiquitous. The vocabulary of acoustics, like that of radioactivity, is gradually entering into common usage.



1 *Loss of hearing due to exposure to noise*

Effects of noise

It is a popular belief that the presence of noise is detrimental to the performance of manual and mental tasks, but reliable evidence in support of this is surprisingly scarce, largely because of the difficulties involved in carrying out controlled research in typical factory conditions.

Laboratory studies have indicated that, even where an initial adverse effect on mental or motor tasks has been observed, it rapidly wears off.

Laboratory tests have, however, shown that continuous, meaningless noise of high intensity (in the region of 100dB) may affect the efficiency of the performance of tasks which require continued and monotonous attention, e.g. routine surveillance of dials or gauges. The nature of the effect is an increase in the frequency of momentary lapses in efficiency rather than a decline in the rate of work, but the consequences of such lapses may be serious.

A recent study in factory conditions has confirmed that, in a film-perforation process, a reduction in noise level from 99 to 89dB resulted in a significant reduction of film breakages attributable to momentary inefficiencies on the part of the operators.

On the other hand, it cannot be denied that a subjective effect of annoyance may result from noise—indeed, noise may be described as 'unwanted sound'. The annoyance appears to be greater when the noise is meaningful or intermittent than when it is random and continuous.

Oral communication, either directly between persons or by means of the telephone, is important in the conduct of industrial operations and in the training of new employees. Ambient noise, particularly when containing frequencies in the range 600–4800c/s, exerts a masking effect on such communication, which is most marked when the information being transmitted is not a routine and familiar message, and costly and dangerous errors may ensue.

Noise and hearing

The major effect of noise, and the one that has been demonstrated beyond all doubt, is that of damage to the hearing of the persons exposed. The initial exposures to excessive noise result in a loss of hearing, probably a fatigue effect, which is temporary in nature—recovery normally occurs completely within a period of hours, or possibly days, after exposure has ceased.

If the exposure is repeated over long periods of time, however, complete recovery does not take place, owing to damage having been incurred by the hair cells which form a vital part of the hearing-perception mechanism. Such hearing loss is permanent and irreparable. Further exposure will result in increased damage. Both types of hearing loss are observed initially at frequencies in the region of 4000c/s (Fig. 1), but as the damage progresses a wider range of frequencies becomes affected.

2 *Transistor sound-level meter*

The assessment of a noise problem

From the management point of view, the first indication of the presence of a noise problem is the subjective awareness of a noise level which makes conversation difficult. The variation of perceived loudness with frequency makes aural assessment of noise level very unreliable, and a factual survey of the problem is always to be recommended.

Such a survey would involve the use of a sound-level meter (Fig. 2) to measure the sound pressure level at appropriate positions, in decibels relative to a reference sound pressure of 0·0002 dyne/cm^2 (this reference level approximates to the threshold of hearing at 1000c/s). Frequency analyses would be made, normally with an octave-band analyser (Fig. 3) or less often with a 1/3-octave or narrow-band analyser. The analysis of continuous noises is normally carried out on site, but where the noise concerned is intermittent, tape recordings may be necessary for subsequent editing and playback, using a closed-loop technique.

Impact noise is more difficult to measure and interpret; one procedure is to take oscillograms from tape recordings, and another is to use, in conjunction with a sound-level meter, an impact-noise analyser which gives an indication of the peak intensity of the sound and provides information from which the duration or waveform of a single impact can be estimated.

The extent to which noise interferes with the transmission of information by speech can be predicted from octave-band analyses, using the levels in the appropriate bands to determine the 'speech interference level' of the noise. Typical values of this index are shown in Table 1.

Table 1. Speech interference at various noise levels

speech interference level	distance for reliability	
	normal voice	shouting
dB	ft	ft
55	3	24
71	0·5	4
83	—	1

Safe levels of noise

Proposals have been made for noise spectra which should not be exceeded if undue hearing loss is to be avoided, and two such spectra are shown in Fig. 4. Spectrum A is of British origin and is based on exposure for 10 years without loss of hearing. Spectrum B, originating in the United States, is based on exposure

3 *Octave-band analyser*

for a normal working lifetime without the resulting loss of hearing being serious enough to affect significantly the ability to understand speech. Where the noise under consideration is continuous, the results of the sound survey can be compared with these standards.

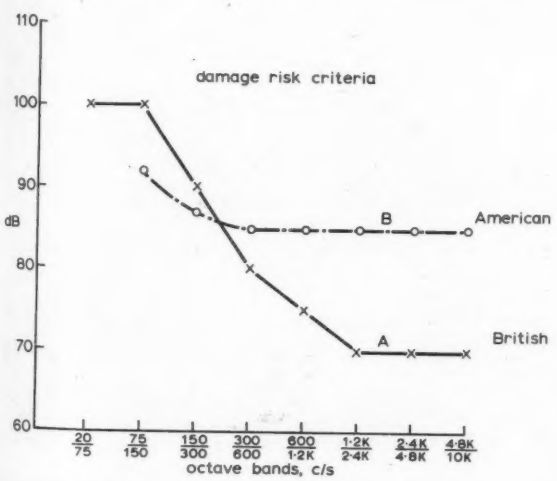
There is, as yet, an incomplete knowledge of the effects of impact and intermittent noise on hearing, but much attention is being paid to the development of integrating noise-dose-meters, which should eventually provide valuable information in this regard.

Even when the noise is continuous and readily measurable, differences in individual susceptibility are so marked that clinical evidence of any hazard to hearing is advisable. Such evidence may be obtained by means of pure-tone audiometric testing of the hearing of a sample of the exposed population. In this form of hearing test, pure tones of reducing intensity are presented to the subject through a headphone, and the hearing threshold for each frequency is determined as the lowest intensity at which the subject indicates that the signal has been heard. The thresholds are then plotted in terms of 'normal hearing', as already illustrated in Fig. 1.

Tests of this type, if carried out at the beginning and end of a working period, can reveal the incidence of temporary hearing loss, which may, with continued exposure, become permanent. These hearing tests need to be administered in a quiet location but are relatively simple and rapid to carry out (Fig. 5).

Noise control

Noise control is based on three principles that are common to the control of any industrial health hazard, namely reduction at source, confinement, and personal protection. The application of these principles to a given situation may merely require sound common sense, but often extensive research and development will be



4 *Safe levels of noise*

5 *Determination of hearing loss by pure-tone audiometry*

necessary. In the former category are the reductions in noise which can result from a reappraisal of materials-handling methods, e.g. the use of rubber-tyred trucks and trolleys and the lining of metal chutes and bins with non-metallic materials. Unfortunately, no such apparent solution is ready at hand for the manager of a press shop or automatic machine-tool shop.

Reduction at source

The problem of reducing noise at its source offers two possible lines of approach. The first recognizes that certain basic machines and processes are widely used in industry and seeks to focus attention on these machines, so that any achievements in noise-reduction measures have a wide field of potential application. Circular saws, for example, have been the subject of study, and the value of stiffening collars in reducing noise has been demonstrated. Other fields of study which would be fruitful are punch presses, automatic machine-tools, packet-filling machines, and the use of compressed-air nozzles.

An alternative view is to regard any noisy machine or process as a combination of a number of individual noise sources, each of which may be further divided into sub-units. Thus a ventilating-fan assembly may be regarded as three noise units—the electric motor, the fan, and the intermediate drive. The electric-motor noise, in turn, is a combination of mechanical noise from bearings and brushes, airflow noise, and magnetic noise.

It could thus be argued that noise-reduction research might well be concentrated on items of universal use, such as ball and roller bearings; the results of such research would then enable quieter motors to be made, with correspondingly quieter machinery in which motors are incorporated. There is undoubtedly much to be said for this fundamental approach, but the results of the

more empirical approach previously mentioned are likely to be of more immediate benefit.

Noise reduction at source as described in the preceding paragraphs is largely in the province of the manufacturer,

6 *Acoustic enclosure for engine testing*

who may find himself at a disadvantage with his competitors if his efforts result in an increased cost of product. The user, however, can make a real contribution to the development of quieter machinery by regarding the noise rating as an essential part of the specification. Practical measures which are open to the works engineer in reducing the noise from existing plant include the fitting of silencers to air exhausts, the substitution of gear trains by fluid drives, and the early replacement of moving parts that are subject to heavy wear.

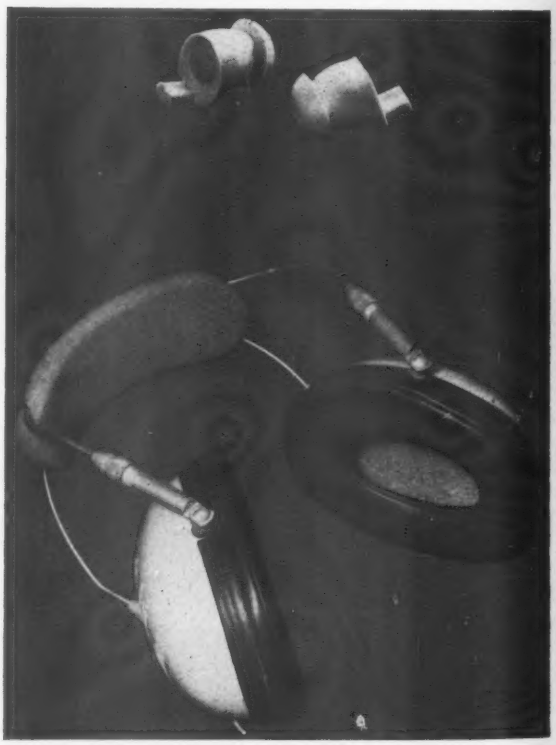
Noise confinement

Confinement of noise that cannot be reduced at source is the next objective, in order that the minimum number of persons shall be exposed. Sound-level measurements near each machine or group of machines, with the other machinery stopped, will indicate the way in which segregation may be carried out. Unfortunately, the trend in modern factory planning is to facilitate production flow by bringing previously segregated processes together into large open workshops, with consequent aggravation of the noise problem. Planning for noise control as well as for production is essential if future trouble is to be avoided.

Enclosure of a machine, to prevent transmission of the noise to the operators, is a common form of confinement (Fig. 6); but equally effective, though less common, is the enclosure of the operator. The construction of the enclosure is determined by the degree of attenuation required, and is normally of a heavy material with a sound-absorbent lining when it is the noise source that is being enclosed. For a given superficial weight of construction, double partitions, preferably with isolated leaves, give greater sound reduction at higher frequencies than single panels.

Apertures, which may be necessary for ventilation or the passage of components, reduce the effectiveness of enclosures, but this effect may be minimized by the use of sound-attenuating ducts leading to the aperture. Barriers placed in the transmission path between the source and exposed personnel are less effective than complete enclosures. They should have a height of several times the wavelength of the sound which it is desired to impede. The best results are obtained when the barrier is close to either the source or the receiving position rather than at an intermediate position.

Acoustic treatment of walls and ceilings or the placing of absorbent cowls above the noise source have limited value because, although the general reverberant noise throughout the shop is thereby reduced, the component of the noise reaching the operator directly from his own



7 *Types of ear defender*
(top) insert ear plugs (bottom) external ear muffs

machine remains unchanged. Normally the reduction achieved does not exceed 6dB.

Personal protection

Certain noisy situations can be dealt with only by providing ear protection, particularly when the degree of hazard is such that preventive measures must be taken immediately. Some excellent types of ear defender are now available, but their provision should not be made an excuse for inaction with regard to other more positive noise-control measures. Insert ear plugs can provide attenuation up to 34dB, and external ear muffs, in which a good fit to the head is ensured by the use of a liquid-filled plastic seal on the edge of the cups, may reach 47dB (see Fig. 7).

In practice, the protection afforded by these devices depends on the consistency with which they are used, and the education of employees as to the purpose, value and care of the ear defenders is essential.

Hearing-conservation programmes

Until further advances have been made in the application of noise-control theory to practical industrial situations, the most probable outcome of an attempt to solve a given noise problem is that the exposure to hazardous noise is reduced but not eliminated. This situation is one which should be kept under surveillance by means of a hearing-conservation programme. Such a programme should include regular environmental-noise measurements, so that changes in exposure owing to additional or altered equipment are not overlooked.

Pre-employment hearing tests on new entrants, followed by a further testing after a short period of employment, would enable the noise-susceptible individuals to be identified before an extended period of exposure had resulted in their suffering a permanent hearing loss. Annual hearing tests on exposed persons would provide clinical confirmation as to the continued effectiveness of the noise-control measures which had been adopted.

Summary

This article has sought to present the problem of noise in industry as it may affect the engineer concerned with works management, and the control measures described are those which lie within his direct sphere of influence. The description of the effects on the health of men and women who are required to operate noisy machinery should, in addition, confirm to designers of electrical and mechanical equipment the value of their efforts to produce quieter products.

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2 HARRIS, M. (*Editor*): 'Handbook of noise control' (McGraw-Hill, 1957)

Advice on the control of noise in buildings and from mechanisms may be obtained from the Building Research Station, the National Physical Laboratory and the National Engineering Laboratory. The latter two organizations will, in suitable cases, carry out field investigations. There are also private consultants and organizations offering similar services. The Occupational Hygiene Service is able to advise on, and investigate, situations where a hazard to hearing is suspected, and to carry out audiometric tests.

AN EVOLVING UNIVERSE?

SINCE 1948, two conflicting theories regarding the nature of the universe have been vying for acceptance. The first is that of an evolving universe, having been created in the remote past and ageing toward its death in the remote future. The second, the 'steady-state'. theory proposed by Bondi, Gold and Hoyle of Cambridge, describes a universe which has always existed and without beginning or end, in which matter is continually being created throughout space to replace that lost to view as the universe expands.

At a Press conference held on the 10th February 1961, Prof. Martin Ryle of the University of Cambridge presented his views on the controversy, based on an eight-year study of radio stars which had been undertaken at Cambridge. An article by Prof. Ryle detailing the system by which these observations were recorded and the apparatus used appeared in the January 1960 *Journal*, p. 14.

His investigation involved three basic problems:

1. To determine the nature, power and distance of radio stars

2. To explore effects which might modify the apparent number of sources observed at different intensities. For example, if the sources were in clusters they could be studied individually when near, but as a composite and more intense source when at a great distance

3. To study the *actual* number of radio sources observed at different intensities and to compare their pattern with those predicted by the different theories.

Using the information obtained, a curve was drawn showing the number of sources falling within different intensity ranges. This curve included far weaker sources than previous surveys, thus providing data at distances and times when the predictions of different cosmological theories were at wide variance.

Comparing this curve with that predicted by the steady-state theory, Prof. Ryle found large discrepancies which he believed could not be explained by either errors in the observations or in their interpretation. He thus concluded that the steady-state theory presented a false picture of the universe, while his own findings were in accord with the evolutionary theories.

LETTERS TO THE EDITOR

Television tower.....J. F. Goodger, ASSOCIATE MEMBER
Content of undergraduate textbooks..C. T. Rivington, M.A., ASSOCIATE MEMBER
Cycles or hertz.....M. G. Scroggie, B.SC., MEMBER
An unusual arrangement.....J. W. Sime, ASSOCIATE
Mutato nomine.....S. A. Vincze, DIPL.-ING., MEMBER
Ampère or Biot–Savart?.....P. Hammond, M.A., ASSOCIATE MEMBER
Britain's engineering manpower.....E. J. Mathieson, D.F.H., MEMBER
National Certificate courses.....H. Campbell, B.SC., ASSOCIATE MEMBER

TELEVISION TOWER

Dear Sir—The article in the October 1960 *Journal*, p. 580, on 'Planning and installing a television station' recalls to mind a television transmitter installation at Stuttgart that shows in a rather novel way the combined skills of civil and electrical engineering.

It is a mast of three parts: virtually a 'smoke-stack' surmounted by a 'crow's-nest' with transmitting aerials above.

The Stuttgart Fernsehturm

The stack conceals high-speed lifts, and its multi-deck crow's-nest, apart from housing transmitting equipment and technicians' accommodation, has public restaurants on two other floors and open viewing galleries. It is 35ft in diameter at ground level and has an over-all height of 700ft; the crow's-nest is 500ft above ground level.

It is said that in the five years since the Stuttgart *Fernsehturm* was opened four million or so people have enjoyed a visit to it and have incidentally more than repaid its cost.—Yours faithfully,

J. F. GOODGER

103 Constance Crescent
24th January 1961 Hayes, Bromley, Kent

[After the receipt of Mr. Goodger's letter, Post Office plans were announced for a 500ft television and radiotelephony tower to be built alongside the Museum telephone exchange in central London. The tower will have a public observation platform at a height of about 460ft (see p. 192).—Editor]

CONTENT OF UNDERGRADUATE TEXTBOOKS

Dear Sir—May I comment on one point in Dr. P. F. Soper's article about undergraduate engineering textbooks in the December 1960 *Journal*, p. 714? Rightly Dr. Soper emphasizes that a university or college author can get much useful help from colleagues. I believe he should seek further afield and try to get the views of engineers teaching in some other universities and colleges.

Most textbooks are quite personal products, and however carefully an author chooses his subject-matter and the approach to it, he will not satisfy completely any lecturer (or student) other than himself—and probably not even him. Nevertheless by suitable inquiry from other engineering teaching staff he can sense how acceptable his scheme for a new book is likely to be, and receive comments which may contribute significantly to the quality of his eventual work and its usefulness to lecturers and students.

This may seem obvious. But I am surprised in practice at the number of prospective authors who seem to plan the itinerary of their long literary journey alone, apart from accepting from a publisher some general travelling advice and a final date for reaching home. With engineering textbooks this is, I believe, wrong. Inevitably, owing to the present rapid expansion in technical education, engineering instruction in Britain will have to depend on books as teaching aids more in the next decade than it does at present. To produce the most widely useful textbooks, prospective authors should, I suggest, let other teaching staff know of what they are setting out to do. Naturally they need not—and indeed will not be able to—accept all the advice they receive.—Yours faithfully,

C. T. RIVINGTON

Blackie and Son Ltd.
16–18 William IV Street
25th January 1961 Charing Cross, London W.C.2

CYCLES OR HERTZ

Dear Sir—I must join issue with my good friend Mr. G. R. M. Garratt (January 1961 *Journal*, p. 21) when he invokes principle to justify his objection to hertz in place of cycles per second.

The joule is a unit of work; and power, which is rate of doing work, could be expressed in joules per second. But for brevity and convenience, this name has been displaced by watt.

The cycle is a unit of phase; and frequency, which is rate of phase change, is expressed in cycles per second. But for brevity and convenience, this name could be displaced by hertz.

Wherein lies the difference in principle that should decide anyone to accept the former and strongly deplore the latter? And since Mr. Garratt quotes his 'campbell' presumably to ridicule it, does he consistently delete knots and substitute nautical miles per hour?

Being so cumbersome, cycles per second and megacycles per second are almost invariably reduced to cycles and megacycles. In America it happens even to the abbreviations, c/s and Mc/s. The disadvantage of this is not mainly that (as Mr. A. C. Davies points out) other units of time are sometimes needed, but that on the occasions when one wants to specify, for example, the number of cycles in a pulse group, one is likely to be seriously misunderstood by those who habitually regard 'cycles' as denoting a frequency. This confusion and difficulty are a result of the illogical opposition to hertz, outside the Continent, owing presumably to nationalistic bias.

If Mr. Davies applied logic to the matter, he would have to make a clean sweep of volts, ohms, farads and all such names, because they too contain no information about their fundamental dimensions.

And how can he seriously state that substituting one syllable for five does not gain brevity?

The common use of cycles to mean cycles per second is eloquent-enough evidence of the demand for greater brevity, but as a way of achieving it is just as unprincipled as it would be to write x in place of dx/dt. Hertz gives just as much brevity with no valid disadvantage.—Yours faithfully,

M. G. SCROGGIE

18 Bromley Common
Bromley, Kent

26th January 1961

AN UNUSUAL ARRANGEMENT

Dear Sir—I was greatly interested in the illustration on p. 22 of the January 1961 *Journal*, showing an unconventional type of long-span construction in the Jerusalem district.

A similar type of construction of a 33kV overhead line surveyed by me between Rannoch power station and Kinlochleven in 1941 incorporates two spans: one, to the best of my recollection, of 1800ft and the other of 1200ft.

I agree with Mr. J. Goldhammer that this unconventional method is both efficient and economical, more particularly where transport of material presents serious difficulties in mountainous country.—Yours faithfully,

J. W. SIME

12 Belleisle Avenue
Uddingston, Glasgow

26th January 1961

MUTATO NOMINE

Dear Sir—I wish to enter a plea for the international adoption of the concise designation 'mutator' (Latin: *mutare* = to alter) for all static apparatus used to transmute alternating current into direct current or vice versa, instead of the cumbersome terms 'rectifier', 'inverter', 'convertor', etc.

In particular I suggest Hg-mutator a.c.–d.c. for mercury-arc rectifier; Hg-mutator d.c.–a.c. for mercury-arc inverter; and Se-, Ge- and Si-mutator for selenium, germanium and silicon rectifier respectively, with the addition of a.c.–d.c. or d.c.–a.c. only if there is any doubt as to the direction of mutation.

The name 'convertor' should be reserved for rotary convertors.—Yours faithfully,

S. A. VINCZE

P.O. Box 485
Wellington, New Zealand

30th January 1961

AMPÈRE OR BIOT–SAVART?

Dear Sir—The custom of associating the names of great men of the past with certain scientific discoveries has much to be said for it. It gives human interest to an otherwise rather dry and mathematical study and encourages a decent humility in view of past achievements, but sometimes it causes a great deal of confusion.

I confess, for instance, to a mild feeling of irritation caused by references to the 'Biot–Savart law' ($H = i\,ds \sin\theta/4\pi r^2 = i\mathbf{ds} \times \mathbf{r}/4\pi r^3$) for the magnetic field of a current-element. When I was a student this law was known as 'Ampère's rule'[1], and the man Biot–Savart (or was it a limited company?) seemed to be an intruder who should be resisted. However, as a teacher one has to get one's facts right and I had to do a little research to find out the truth of the matter.

The first discovery is that it certainly is not Ampère's law, although Ampère knew about it. He neither liked it nor used it, because he did not believe in the magnetic field[2]. He believed in the force between current-elements and developed a formula for this force, which in vector notation is:

$$F = ii'r\left[\frac{2}{r^3}(\mathbf{ds}.\mathbf{ds}') - \frac{3}{r^5}(\mathbf{ds}.\mathbf{r})(\mathbf{ds}'.\mathbf{r})\right]$$

As far as I know, I have never met anybody who uses this formula, although it is quoted in several books[3,4].

If it is not Ampère's law, what about Biot–Savart? Jean-Baptiste Biot was Ampère's colleague at the Collège de France where both were professors. Félix Savart was a good deal younger than Biot and Ampère. For a while he was Ampère's assistant and after his death succeeded him as professor.

All three were present at the historic meeting of the French Academy in 1820 at which Arago demonstrated Oersted's discovery that an electric current deflects a magnetic needle. Ampère immediately began a series of brilliant researches which led him to postulate that magnetism can be attributed to molecular currents, and this hypothesis made him dispense with magnetic poles or fluids.

Biot and Savart did not work so fast or think so deeply. They clung to the idea of two magnetic fluids and somewhat to Ampère's annoyance wrote a paper in which they attributed Oersted's results to a magnetic force. Their formula for this force was that it varied inversely as the perpendicular distance from a long straight current[5,6]. They said nothing about current-elements, and one is driven to the conclusion that $H = i\mathbf{ds} \times \mathbf{r}/4\pi r^3$ can be attributed neither to Ampère nor to Biot and Savart.

The man who actually produced the formula was Laplace, who generalized the result obtained by Biot and Savart. Ampère discussed Laplace's formula in detail and showed that it would lead to results identical with his own as long as only complete circuits were being considered. But he had strong misgivings about Laplace's result when this was applied to the action between two current-elements. The trouble was that Laplace's formula did not make the action and reaction between current-elements equal and opposite.

Laplace's formula led to a law of interaction which was first stated explicitly by the German physicist Grassmann[7] some 25 years later. In vector notation it is:

$$\boldsymbol{F} = ii'\mathbf{ds}' \times (\mathbf{ds} \times \mathbf{r})/4\pi r^3 = i'\mathbf{ds}' \times \boldsymbol{B}$$

where $\boldsymbol{B}$ is derived from Laplace's formula. Grassmann ignored Ampère's difficulty, and it was left to Oliver Heaviside many years later to put his finger on the explanation. This he did by pointing out that no current would flow in Ampère's current-elements!

Heaviside proposed a 'rational' current-element immersed in a conducting fluid. For two such elements, Newton's law of action and reaction was obeyed by both Ampère's and Grassmann's formula; and since Grassmann's formula could be expressed as a product of $\mathbf{ds}'$ and $\boldsymbol{B}$, while Ampère's formula could not, Grassmann's formula won the day. In spite of Ampère's hypothesis of molecular currents, electrical engineers found the concept of magnetic field far too convenient for them to dispense with it.

One further difficulty remained. Suppose the current-elements were replaced by moving charges, would not Laplace's and Grassmann's formulae lead to a violation of Newton's third law? There would indeed be such a violation if the forces on the charges only were considered, but it must be remembered that the motion of charges is accompanied by a changing electromagnetic field and that momentum has to be associated with this field, which behaves in a similar manner to Heaviside's conducting ocean. If this momentum is considered, all is well with Newton's law. So Ampère need not have worried.

But what *are* we going to call the Ampère–Biot–Savart–Laplace–Grassmann–Heaviside formula?—Yours faithfully,

P. HAMMOND
University of Cambridge
Engineering Laboratory
Trumpington Street
Cambridge

9th February 1961

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2 *Mémoires de l'Académie des Sciences*, 1825, **6**, p. 175
3 MAXWELL, J. C.: 'Electricity and magnetism' (Oxford: Clarendon Press, 1873), Part 4, chapter 2
4 WHITTAKER, SIR EDMUND: 'History of the theories of aether and electricity' (Nelson, 1953), **1**, p. 86
5 *Annales de Chimie*, 1820, **15**, p. 222
6 *Journal de Physique*, 1820, **91**, p. 151
7 *Annalen der Physik*, 1845, **64**, p. 1

[An article by Mr. Hammond on the life of Ampère will appear in a forthcoming issue of the *Journal*.—Editor]

BRITAIN'S ENGINEERING MANPOWER

Dear Sir—I refer to the letter in the January 1961 *Journal*, p. 21, regarding a Royal Society for Electrical Technicians, who, although of a good academic standard and of wide practical experience, are not eligible to become Chartered Electrical Engineers.

The attention of practising Chartered Electrical Engineers should be called to the fact that the Association of Supervising Electrical Engineers fulfils this requirement to a very large extent. Being a Member, Associate Member or Graduate of this Association gives such a technician a *cachet* that well fits him for a post in an organization which calls for such a qualification.

The Association works in the closest co-operation with The Institution, which furnishes supplementary library facilities, through the A.S.E.E. Librarian, to the members of the Association; permits the Association to make use of the Institution Lecture Theatre for meetings in the A.S.E.E. national lecture programme; and provides accommodation for meetings of the A.S.E.E. Technical and Education and Training Committees.

The Association was founded in 1914, and during the past five years has become very strong in the technician field. The conditions of entry are now such that a person admitted is in every way qualified electrically, technically and practically and can confidently be relied on to take his rightful place on the ladder of the electrical engineering profession.

Each year, some 400 lecture meetings are conducted by the Association's London and Provincial branches: these are of a sufficiently comprehensive nature to permit engineers and technicians to keep abreast of modern developments in the electrical and allied industries.—Yours faithfully,

E. J. MATHIESON
43 Wellington Park
Clifton, Bristol 8

11th February 1961

NATIONAL CERTIFICATE COURSES

Dear Sir—I have noted the comment of the Chairman of the Joint Committee for National Certificates in Electrical Engineering on my letter in the December 1960 *Journal*, p. 708. He is mistaken in assuming that I did not guide the pupil properly—i.e. into a G.C.E. course. The boy sat the G.C.E. examination and passed, by a good margin, in English language, mathematics and engineering drawing, but

he failed narrowly in physics. So, under the regulations at present operating, he could not be exempted from *any* subject of the S.1 course.

In my opinion, if such a student is accepted for a National Certificate course at all, he should be placed in the S.2 course and be given additional instruction in such parts of the S.1 syllabus as is deemed desirable. It is absurd that, after achieving success in fifth-form studies, he should go to a technical college to repeat work of approximately third-form standard.

Unfortunately, however, the recommendations of head teachers cannot now be taken into consideration because of the regulations of the National Committees.

In July last, two of my pupils—a boy and a girl—passed the G.C.E. examination at one sitting in six subjects, including English language, mathematics, chemistry and biology. Only one or two children in a hundred of a whole age group can achieve such success as this. Nevertheless, on entry to a National Certificate course in chemistry, they were placed in the S.1 course because they had not studied physics. S.2, plus S.1 physics, was what they should have studied—and presumably what they would have studied but for inflexible regulations which inhibit the development of our best brains. —Yours faithfully,

H. CAMPBELL

Headmaster
Grange Park Secondary Technical School
Broadway
St. Helens, Lancs.

15th February 1961

Better opportunities in technical education

The author of this article has had some 60 years' close practical connection with electrical engineering education. In the article, he covers, from his own personal experience, the historical background of the White Paper (Cmnd. 1254) 'Better opportunities in technical education'. The Institution appears as an important figure in this background. Sir Willis Jackson, in the February 1961 Journal, p. 97, summarized the White Paper proposals in his article 'A logical pattern for technical education'.

F. T. CHAPMAN, C.B.E., D.SC.(ENG.), B.SC., MEMBER

SIR Willis Jackson gave last month a clear summary of the new proposals by the Ministry of Education which are set out in the recent White Paper (Cmnd. 1254) 'Better opportunities in technical education'. This document proposes a scheme of courses for technicians, craftsmen and operatives for future use and gives a brief statement of the present position. The issue of this document has been preceded by a long period of development in technical education which can be traced over more than 80 years. The period from 1902 to the present day falls naturally into four parts, namely 1902–11, 1911–20, 1920–39, and 1939–60.

1902–11

The Education Act of 1902 laid on local authorities the duty of providing education of all forms, including technical education, in their respective areas. The authorities at once began to increase the limited number of technical classes existing at that time, and it was then that I began to teach electricity in evening classes in a large industrial city, which I continued to do throughout this period.

The students who attended these classes were mainly ex-elementary schoolboys, with a sprinkling of ex-secondary scholars. They were apprentices or improvers of different grades, and their ages were 16 years upwards. Most of them were working a 53-hour week, with frequent overtime and night shifts. The foremen of those days were not sympathetic to requests for release and consequently attendance was somewhat irregular.

The students had the rather vague aim of becoming 'electrical engineers', their proximate target being to get into the drawing office if in manufacturing works, or onto the switchboard if in the power-supply industry. Many came with little knowledge of mathematics and made their first acquaintance with algebra through Ohm's law. There was a good sprinkling of able individuals among them, however, for whom there was no alternative technical education available; these in their time have taken high places in the industry.

Available examinations

Some students entered for examinations, of which the following were available:

(a) The Science and Art Examinations administered by the Board of Education from South Kensington; this excellent series of examinations was used by secondary and evening schools, so that some students arrived having already passed Stages 1 and 2 in some science and mathematical subjects
(b) Examinations of the City and Guilds Institute in telegraphy and telephony; electric lighting and power supply; and electric wiremen's work, which included practical work
(c) Examinations of examining unions in some areas of the country.

In this period, students attended only one evening per week for the most part, but some local authorities offered grouped courses leading to special certificates. These were awarded on the results of examinations, some of which were set by the teachers or by examining unions; or the external examinations in (a) and (b) above were used. The certificates had only local currency and were never very popular with students. In 1911, the Board of Education took steps, described below, to strengthen the grouped-course system.

In 1903, a new factor appeared in the form of the establishment by the University of London of the external (and internal) degree of B.Sc. in engineering, which gave to students of engineering subjects the same valuable opportunity to obtain a university qualification as was already enjoyed by students of science and of arts. This was a more attractive goal than a local certificate for able and hard-working students with ambition. Successes in degree examinations were a source of prestige to technical institutes, with the result that the development of grouped courses was retarded. The University did not require the submission of course-work until 1936, and so the development of advanced laboratory work was neglected.

Nevertheless, as the number of students increased, it became possible to increase the number of stages of instruction, and the authorities became more successful in persuading students to take grouped courses and began to provide advanced courses for a minority of students. At the same time, there was some growth of full-time and part-time day classes, and in the central technical institutes of some of the larger towns and in the London polytechnics, engineering departments (including electrical engineering) were already of considerable size.

Improved facilities introduced

With the object of improving facilities for technical education and raising its quality, the Board of Education took two important steps in 1911. First, it published a document 'Science examinations and grouped-course certificates' (Circular 776) and, secondly, it began to build up a Technical Inspectorate of inspectors who were qualified by training, by teaching and by industrial experience to give authoritative guidance and advice to the Board and to local authorities and schools on technical education.

In Circular 776, the Board announced the withdrawal of a large number of the science and art examinations and set out proposals for the endorsement by the Board of local grouped-course certificates provided that the courses and the examinations fulfilled certain conditions. The Board recognized certification of 3-year Senior Courses and 2-year Higher Courses for evening and part-time day students, and for full-time students a Course Diploma for a 2-year course and a Higher Course Diploma for a 3-year course. Courses for apprentices working under a sandwich system would be classified as full-time courses.

The general conditions for endorsement were very similar to those imposed for recognition of courses for National Certificates and Diplomas at the present time.

1911–20

The First World War occupied a large part of this period, and its effect, on one hand, was to delay the development of facilities for technical education and, on the other, to cause a great increase in the demand for technical instruction at all levels, including craft courses. The members of the growing Technical Inspectorate were very active during this period. They made intimate contacts with industry and produced a series of reports on education for mechanical and electrical engineering, building and other industries; they brought the Board of Education into contact with the professional institutions, including The Institutions of Mechanical and Electrical Engineers. Both these institutions had established systems of examinations for the admission of members (The Institution of Electrical Engineers in 1913), but both of these were external examinations needing no course-work and tended to draw students away from grouped courses.

1920–39

At the beginning of this period, the drift away of many of the better students, from grouped courses to preparation for external examinations, was causing considerable dissatisfaction to the Board of Education and to local authorities. At the same time, negotiations were going on between the Board and representatives of The Institution of Mechanical Engineers, who were dissatisfied with their own examination system, regarding methods by which technical colleges could co-operate with The Institution of Mechanical Engineers to bring about better preparation of candidates for these examinations.

At this stage an opportune suggestion came from Rugby Technical College that their grouped-course certificates in electrical engineering, already endorsed by the Board, would be more attractive to students if they were also endorsed by The Institution of Electrical Engineers. The idea of endorsement by a professional body found immediate acceptance by the Board and was brought into the negotiations with The Institution of Mechanical Engineers. The Institution of Electrical Engineers was kept informed of these negotiations.

The National Certificate

A Joint Standing Committee of the Board and The Institution of Mechanical Engineers was formed, and its first meeting was held on the 21st January 1921 with myself as secretary; among other business, the title National Certificate was approved for the endorsed certificate, though only after considerable discussion. The committee was the forerunner of the many joint committees which exist today. The first set of rules to govern the issue of the new certificates was drawn up by the Board and issued in 1922. The first meeting of the Joint Committee on National Certificates in Electrical Engineering took place at The Institution of Electrical Engineers on the 1st November 1922.*

The professional institutions undertook an important part in the operation of the scheme of National Certificates. They provided the premises, staff and equipment for the administration of the awards; they appointed and paid the assessors, who reported to them; and the fees due from colleges and students were paid to them.

The professional institutions became equal partners with the Board in fixing the standards of attainment required for the award of certificates.

It was expected by the colleges that the holders of Higher National Certificates would be able to qualify for very valuable exemptions from the examinations of The Institution of Electrical Engineers and so find a convenient path to membership. The Institution, for its part, was anxious that

* Prof. E. W. Marchant and Dr. Chapman are the two surviving members of this committee

a good path should be available to those potential members who were obliged to obtain their academic qualifications by part-time study.

Exemptions granted by The Institution

By 1925, candidates who had been exempted from the early stages of their courses were coming forward for awards in both the ordinary and higher grades. At their meeting on the 19th February 1925, the Council of The Institution approved a recommendation from the Examinations Committee that the Higher National Certificates and Diplomas should be accepted in lieu of Part I of the Associate Membership examination, provided that the candidate satisfied The Institution in the subject of English Essay. In May 1926, The Institution extended its exemptions to cover all the technical subjects of its examination, and in June 1932 complete exemption was given provided that the candidates obtained credits in two advanced electrical subjects.

This action of The Institution gave great encouragement to local authorities and governing bodies, and widespread improvements in staffing and equipment were made to provide for the students to whom the new prestige of the courses was a strong attraction. Although fairly rigorous conditions of entry to the courses were in force, the number of failures and marginal passes was high, and The Institution found it necessary to require credit passes in, and the endorsement of additional subjects on, certificates to make them acceptable for exemption purposes. In this way, an advance in the over-all standard of the certificate was secured to suit the case of those with the ability to reach it, while still leaving the normal certificate as a goal for those for whom membership was an impossible or unsuitable aim.

During the rest of this period, the technological range of electrical engineering increased greatly, as the *Proceedings* of The Institution bear witness, and in order to be able to take a full part in The Institution's activities members needed higher academic qualifications than before. It was thus desirable to raise the standard of The Institution's examinations and conditions of admission, with corresponding reactions on the conditions required for exemption through National Certificates; the distinction between National Certificates which did, and those which did not, carry exemption became more marked, and the unsatisfactory position arose that colleges were attempting to cater for two groups of students with different objectives in the same classes.

1939–60

The extensive technical developments which occurred during the Second World War affected the electrical industry markedly and led to a large increase in technical employment within it. Some of this increased demand was for personnel with high technological qualifications such as The Institution required of its Associate Members, but a much larger portion of it was for personnel with qualifications of a different kind and more or less of the level of the Higher National Certificate that did not qualify for exemption. Much larger numbers were now coming to the colleges for courses, and it became possible to contemplate the provision of separate courses with curricula appropriate to each group.

Professional electrical engineers and technicians

In 1941, the Council of The Institution set up a Post-War Planning Committee with a sub-committee on 'Education and training and personnel'. The sub-committee published reports in 1943, 1944 and 1945 on 'Education and training for engineers'. In the 1944 report, a group called 'technicians' was distinguished as needing a form of education intermediate between that required by craftsmen and that by professional engineers. In the report of 1945, the numerical preponderance of technicians was emphasized, and a draft scheme of courses to provide for all groups was presented.

In 1949, The Institution published a preliminary memorandum 'The personnel of the electrical industry' in which there appeared the first definitions of 'a professional electrical engineer' and 'an electrical technician'. These definitions, in an expanded form, have been widely adopted at home and internationally.

In 1950, a Joint Committee representing all branches of the industry, which had been set up on the instigation of the Council, published, with the approval of all concerned, a report entitled 'Education and training of electrical technicians'. At this time, some objection was raised against the use of the word 'technician' as applied to this group of personnel; it was regarded as derogatory in some quarters, but it is now fully accepted.

Further co-operation with the Ministry

After the publication of these reports, the form and standard of The Institution's examinations were changed, and an exhaustive scrutiny of existing National Certificate and Diploma schemes was carried out by The Institution's officers in co-operation with inspectors of the Ministry of Education. In 1958, there was published a Joint Statement by the Ministry and The Institution, which referred to a number of recent changes in the organization of technical-college courses, such as the introduction of the Diploma in Technology (Engineering) and the increase in the number of sandwich courses. A number of examples were given of ways in which college courses could be built up to enable successful candidates to fulfil The Institution's requirements for exemption from its revised examinations. The document ended by saying that the Ministry and The Institution had under consideration the needs of students for whom admission to membership was not a suitable initial target, and they suggested that courses for these students might diverge at a suitable point from the courses in the examples they had previously given. In addition, they had in mind the need for 2-year sandwich courses for technicians, with a more practical bias than those for Higher National Diplomas.

Subsequent consultation between the two bodies, and with other bodies concerned, led to the recent White Paper.

Conclusion

This brief historical survey will bring to the notice of members the significant part which The Institution has played, through its committees and its officers, in influencing opinion and guiding recent development in technical education to the stage represented by the White Paper.

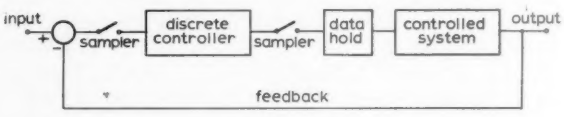
THE JOURNAL DIGEST: PAPERS READ

The articles in this regular monthly feature are based on current papers read at Institution meetings. They are written by the authors of the papers, who have been asked to make the articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics discussed. While the articles bring out the main points and conclusions of the papers, their contents are not necessarily confined to the subject-matter of the original papers

Analogue computer for sampled-data control systems

A brief article based on a Measurement and Control Section paper (3341) 'Discrete analogue-computer compensation of sampled-data control systems' by T. Glucharoff, M.E. The paper was published individually in November 1960 and is republished this month in Part B of the Proceedings. It was read at Savoy Place on the 15th November 1960 before the Section. The author is in the School of Electrical Engineering, University of New South Wales, Australia.

ANALOGUE computers are widely used at present in the investigation of control systems in which all signals are continuous functions of time. However, if signals appear at some point of the system in the form of pulses or numbers, a conventional analogue computer cannot be used.



1 *Discrete controller in a feedback system*

Digital computers in control systems

In recent years, following the increased reliability of electronic devices, digital computers have been introduced in control systems. In a digital computer, information is represented by numbers, and this allows the application of sampling techniques, so that a computer may be shared by a number of control systems. In fact, if sampling is employed, a digital computer can perform a variety of functions simultaneously, and may be used to control the operations of all individual systems in a large-scale automatic plant.

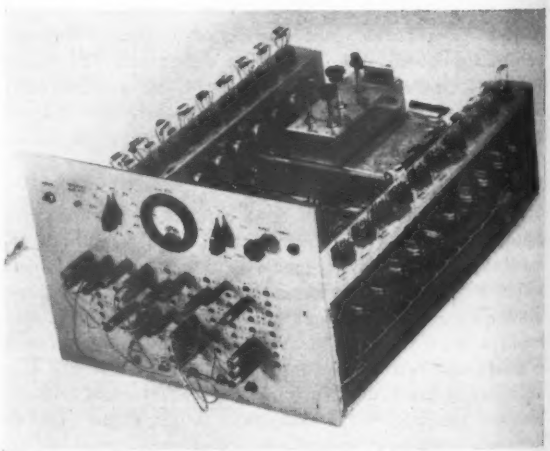
One problem encountered in such applications is the compensation of a feedback control system (Fig. 1). The digital computer acts as a discrete controller, with periodic samplers at its input and output, and the function of the data hold is to reconstruct from the sampled signal the continuous signal before it is applied to the input of the controlled system.

The purpose of the discrete controller is to force satisfactory feedback control. However, it has been found that the adjustment of the controller parameters for optimum operation may be very difficult if the system characteristics are not known with high accuracy. Modifications in the programming of digital computers by trial and error are tedious unless special-purpose computers are employed. Furthermore, the high cost of digital computers requires efficient operation, and the use of a digital computer to compensate a single system would be uneconomical.

Pulsed analogue computers

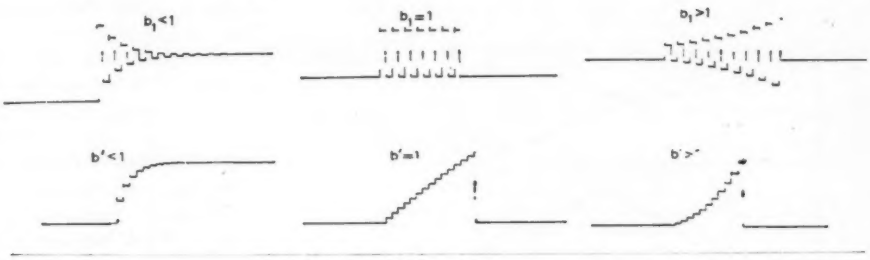
Discrete compensation of a feedback system can also be achieved by means of a pulsed analogue computer. In a pulsed analogue computer, all signals appear in the form of pulses which faithfully represent the operation of a digital controller. The simplicity of programming and the low cost allow experimental studies with analogue computers, and these computers provide better insight into the behaviour of a system than digital computers normally permit. Moreover, analogue–digital and digital–analogue convertors, which are necessary when a digital computer is employed to compensate a feedback system, are not required.

The basic operations in a pulsed analogue computer are sampling, holding and time-delay. These operations are performed in a purely electronic manner by means of operational amplifiers and diode switches. The only arithmetic operation is addition, for which summing operational amplifiers are used. The setting-up is similar to that of a conventional analogue computer, and a patching board allows the interconnection of the operational amplifiers (Fig. 2).



2 *A pulsed analogue computer containing 20 operational amplifiers*

A pulsed analogue computer bears the same relation to difference equations as does a conventional analogue computer to differential equations. Thus, a pulsed analogue computer can be used to solve difference equations, and this is usually reduced to the determination of the responses of pulse transfer functions. Fig. 3 shows the step responses of several simple pulse transfer functions, from which the discrete nature of the signals is clearly evident.



3 *Step response of pulse transfer functions with a single negative real pole b_1, or a single positive real pole b'*

Sampled-data systems usually contain sampled and continuous signals. For research and design purposes, such systems can be simulated by means of a pulsed analogue computer and conventional analogue techniques. Analogue computers are relatively easy to construct, operate and maintain, and simulation helps to bridge the gap between mathematical symbolism and physical reality.

Conclusions

Pulsed analogue computers have been found very useful in the investigation of sampled-data systems. A pulsed analogue computer can also be used to determine the parameters of the discrete controller in a feedback system for optimum operation before a digital computer is employed, or it can itself be used as a discrete controller. 621-526:681.142

Electrical character of an arc furnace

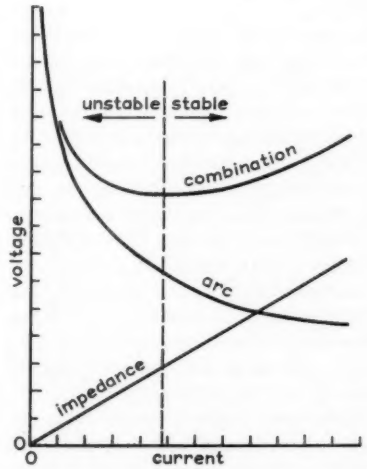
A short article based on a Utilization Section paper (3328) 'The determination of the electrical characteristics of an arc furnace' by J. Ravenscroft, B.Sc., Associate Member. The paper was published individually in September 1960 and will be republished in Part A of the Proceedings. It was read before the Section on the 8th December 1960 at Savoy Place (see p. 200). The author is with Steel, Peech and Tozer and was formerly with the British Iron and Steel Research Association.

In the 3-phase arc furnace, the arcs are struck between the material constituting the charge and three vertical electrodes, of graphite or carbon, used as consumable conductors in the interior of the furnace. These electrodes, firmly held by clamps acting as both supports and current collectors, are connected by means of copper busbars and flexible cables to the secondary side of the step-down transformer, whose primary is connected to the electricity-supply network, either directly or through an inductive reactor.

The transformer primary winding has several tappings to give different arc voltages to suit the varying furnace conditions. Automatic electrode regulators are used to give a uniform power input.

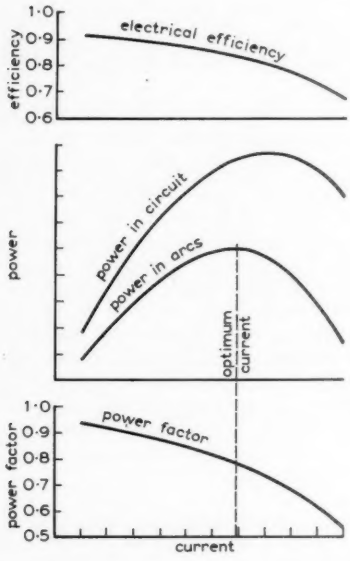
Arc characteristics and circuit reactance

The heat input to the furnace and its charge is generated in the three arcs, but the electric arc itself has a negative voltage/current characteristic, which means that it is inherently unstable. Hence, resistance or inductive reactance is connected in series with the arc so that a combination circuit is obtained having, in part, a stable positive voltage/current characteristic, where voltage drop increases as current increases (Fig. 1).



1 *Resistance or inductive reactance in series with the arc gives a stable voltage/current characteristic*

In large furnace installations (10MVA rating and over), there is usually sufficient inherent impedance in the equipment and leads to provide arc stability, but for small arc furnaces a supplementary reactor is necessary.



2 *Typical electric-arc-furnace characteristics*

In addition to its effect on arc stability, reactance in the circuit reduces current surges and short-circuits common to furnace operation.

Electrical characteristics

The electrical characteristics of an arc furnace (Fig. 2) are such that, for any given voltage tap, the power input to the furnace transformer (the circuit power) increases as the electrodes are lowered to increase current, levels off, and finally decreases as the arc current is further increased. The useful power input, i.e. the power dissipated in the arcs, also increases at first with an increase of current, and the arc-power/furnace-current characteristic lies below the circuit-power curve, reaching a maximum value at a current slightly less than that corresponding to maximum circuit power.

The peak in the arc-power characteristic represents the highest useful power that can be put into the furnace on the given transformer voltage-tap in those circuit conditions. The current corresponding to maximum arc power is usually termed the optimum current for that particular voltage.

If the total furnace impedance is high, the load current can approach or exceed the optimum value, and it is important that the optimum currents are forecast accurately so that the load does not exceed these values during normal operation of the furnace, thereby wasting power. Conversely, if the total impedance is very low, optimum current occurs at extreme overload conditions, and so the maximum working currents must be adjusted to correspond to the rating of the furnace transformer, and not the optimum values.

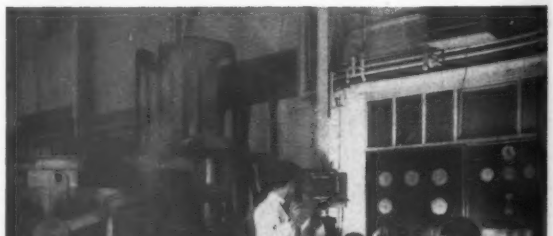
Electrical efficiency, defined by the ratio of arc power to circuit power, decreases steadily with increase of furnace load, falling off rapidly after the arc power has reached a maximum. The over-all circuit power factor also falls steadily with increase of load, and its minimum value corresponds to zero arc power and maximum furnace current, i.e. when the three arcs are short-circuited.

Determination of furnace curves

For the correct adjustment of the working currents of an arc furnace, a knowledge of the electrical characteristics is essential. Three different methods for the determination of furnace power curves are considered in the paper, and a comparison is made between the three methods by applying each, in turn, to the determination of the electrical characteristics of a 10cwt Héroult-type 3-phase arc furnace.

In the first method, the characteristics are obtained directly from observations on the furnace during normal operation and in short-circuit conditions. In the second method, the furnace curves are calculated by using simple formulae obtained from an analysis of an equivalent circuit for the 3-phase arc furnace. The third and simplest method treats the furnace as a balanced 3-phase load and utilizes a current-locus diagram to calculate operating points on the characteristics.

The direct method has limited application in practice because of the difficulties involved in making a prolonged series of tests on a production furnace.



3 *Making a short-circuit test on the B.I.S.R.A. 10cwt experimental arc furnace*

If a series of short-circuit tests are made to determine the values for the constants in the furnace equivalent circuit, the complete furnace characteristics can be calculated with considerable accuracy.

When the working-current range is well below the optimum

level, the use of a simple current-locus diagram for the determination of the furnace curves gives results in close agreement with those obtained by the two other methods.

In the case of the 10cwt furnace, the simple locus-diagram treatment gives results of sufficient accuracy for all practical purposes, and the characteristic curves show that the furnace is most efficient, electrically, when operated on the highest voltage tapping. 621.365.2

Digital computers in power-system analysis

A Supply Section paper (3484) with the above title, by P. P. Gupta, Ph.D., B.Sc., Graduate, and Prof. M. W. Humphrey Davies, M.Sc., Member, was read before the Section on the 18th January 1961 at Savoy Place (see p. 197). This short account is based on the paper, which was published individually in January 1961 and will be republished in Part A of the Proceedings. Dr. Gupta was formerly in the Electrical Engineering Department, Queen Mary College, London, and with Associated Electrical Industries Ltd., and is now with Ferranti Ltd. Prof. Humphrey Davies is Professor of Electrical Engineering, Queen Mary College, London.

Paper 3259 'A general method of digital network analysis particularly suitable for use with low-speed computers' by M. N. John was read at the same meeting (see p. 166).

METHODS of using an electronic digital computer for the solution of problems in power-system analysis which are at present investigated by network analysers are illustrated by two programmes. The first programme deals with the conventional form of load study for power networks, and the second programme is designed for investigations of transient stability.

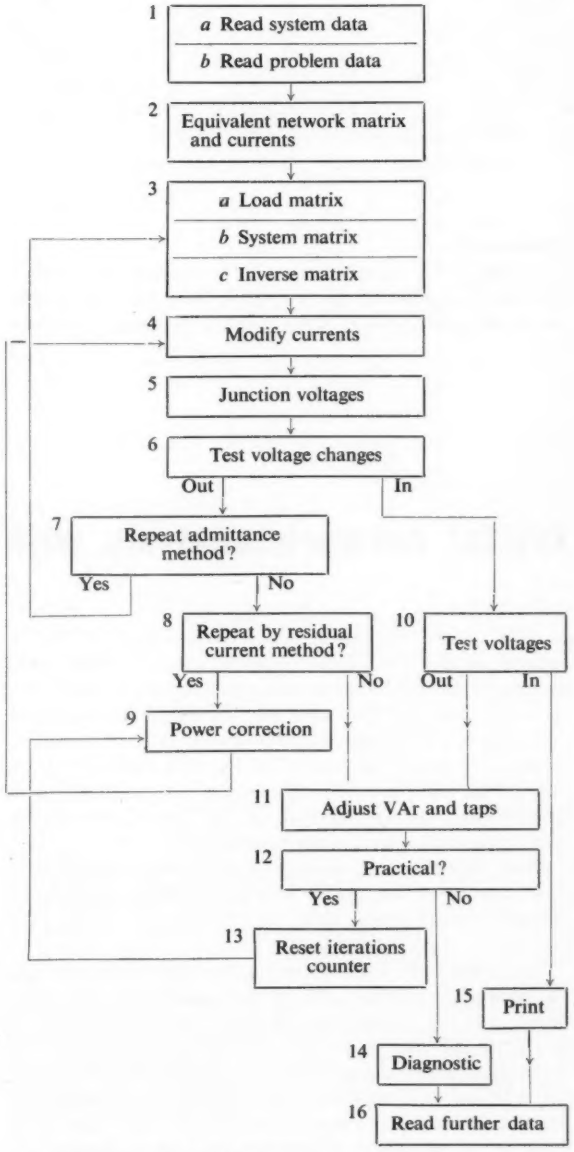
Analytical basis

Nodal equations are the basis of analysis for both programmes. Generators, loads and transformer-tap variations can be represented by a combination of equivalent admittances and current sources. The load-study programme can accept a network with up to 33 busbars and 120 lines when used with a Pegasus I computer having an 8000-word store. Normally a complete solution can be obtained in less than 15min.

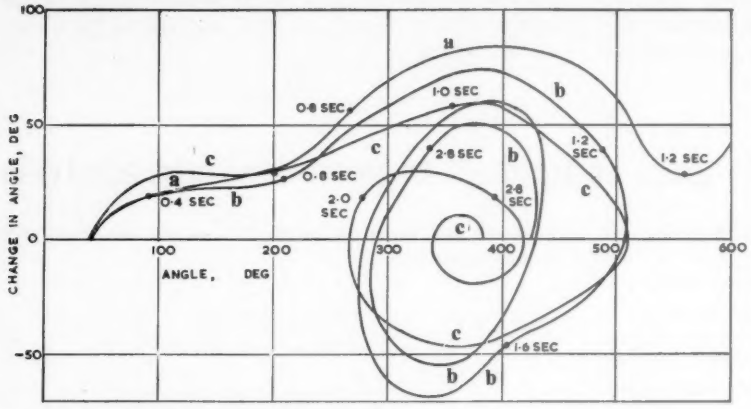
The main problem with this programme has been to develop a method of automatic control by which transformer-tap settings and generator reactive power can be adjusted to bring all busbar voltages within the necessary limits and to ensure the best operating conditions. The flow diagram for the load-study programme is given in Fig. 1.

The input data are similar to those required for a network analyser, and the output can include system losses, busbar voltages in amplitude and phase, line flows and generator outputs. The computer calls attention to any overloaded lines.

The transient-stability programme can deal with systems of up to 24 machines. It starts with the output of a load study defining the initial conditions and is in two parts: the first part calculates and assembles the parameters for the second, which calculates the time variations of machine rotor-angles following specified sequences of disturbances. The rest of the input is again similar to that required for a network analyser. The two parts of the programme can usually be completed in 30min.



1 *Flow diagram for load studies*



2 *Single-machine transient-stability study*
a slower governor action b faster governor action c test results

Refinements

A number of refinements that are impracticable with a conventional network analyser have been introduced into the stability programme. It is possible to represent the effects of voltage-regulator and governor action, saliency, saturation and the decay of air-gap flux density, and to provide for a complicated sequence of circuit-breaker operations. Fig. 2 illustrates the use of the programme to simulate the results of a test in which a generator slipped a pole-pair and then resynchronized. Conventional calculations made the machine permanently unstable.

Both programmes have been used successfully on a number of problems of practical value, and it is expected that similar programmes will be developed for the solution of larger networks by the use of computers with magnetic tape. These programmes do the work of a network analyser, with a considerable saving of time and at less cost.

The effort of getting used to a new method of presenting data is amply rewarded by the ability of the computer to make decisions normally made by the engineering staff as a network-analyser study proceeds. It is expected that still more general methods will be developed for the larger computers of the future.

621.311.1:681.142

Digital network analysis with low-speed computers

A short article based on a Supply Section paper (3259) 'A general method of digital network analysis particularly suitable for use with low-speed computers' by M. N. John, B.Sc., Associate Member. The paper was published individually in May 1960 and will be republished in Part A of the Proceedings. It was read before the Section on the 18th January 1961 at Savoy Place (see p. 197). The author was formerly with Metropolitan-Vickers Electrical Co. Ltd. and is now with the United Kingdom Atomic Energy Authority.

Paper 3484 'Digital computers in power-system analysis' by P. P. Gupta and Prof. M. W. Humphrey Davies was read at the same meeting (see p. 165).

The traditional tool for the analysis of complex power-network problems is the network analyser in one of its forms, and it is unlikely that the use of digital computers in this field will entirely replace such existing and well tried methods, chiefly because numerical methods do not provide the physical correspondence of controls and parameters which is inherent in analogue representation. There will often, however, be circumstances in which this feature alone is not sufficient to justify the installation of the special-purpose analyser rather than the general-purpose digital computer, e.g. where the solution of network problems occurs as only part of the work of a group requiring other forms of computational assistance.

For this reason and because certain effects, such as those of phase-shifting transformers or voltage regulators, can be represented on a network analyser only with difficulty, it is to be expected that the use of digital methods for network analysis will increase.

The present evidence for such an increase, however, indicates that it is chiefly concerned with programmes for large high-speed computers, with the result that digital network analyses tend to be restricted to piecemeal studies at computing centres, although it is the smaller low-speed computers which are likely to be used for the general computational assistance referred to above. Although it was felt that the development of a method particularly suited for use with such computers was justified, this method has also been proved suitable with high-speed computers, and it is believed that its inherent flexibility should permit its future use as the basis of self-balancing programmes in which restraints can be continuously incorporated into the solution as required.

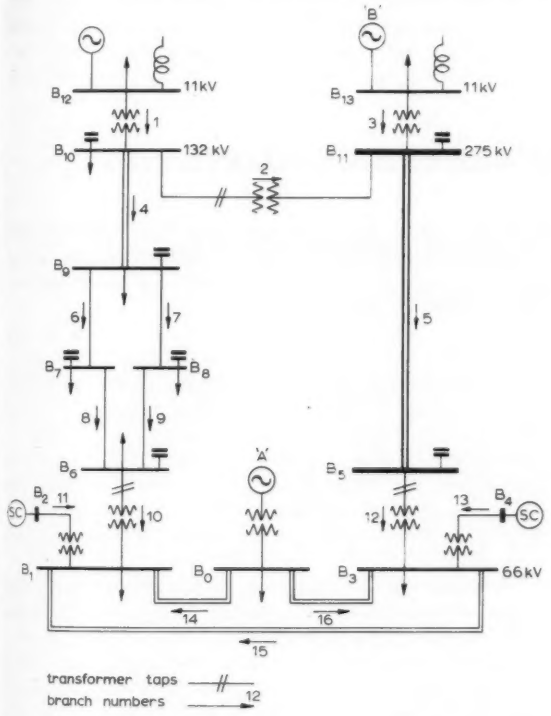
Features of the method

Load-flow conditions are obtained by the setting-up and solution of the network nodal equations, written in matrix form as:

$$Yd = I$$

These equations relate the difference voltages d of busbars above that of a reference or take-up busbar and the injected currents I at each busbar through the nodal admittances Y.

Whatever the numerical method of solution of the nodal equations, the approach to required network conditions must be iterative to satisfy the restraints of constant power loads and generation. It was thought that an iterative solution of the nodal equations themselves could be 'mixed' with the system iterations without seriously increasing the over-all convergence time. The resulting method uses a modified form of the Gauss–Seidel process for the solution of linear equations, and the original hypothesis has been verified for typical power-system networks.



1 *Definition of sample system*

Particular advantages which result from the use of an over-all iterative procedure are:

(a) scaling for fixed-point computation is reduced to a minimum and programming is made correspondingly more simple

(b) network coefficients are unaltered; thus physical correspondence is retained, and data changes involve a minimum of recomputation. This feature is further facilitated by the treatment of transformer tap effects as injected currents

(c) controlled acceleration of the over-all convergence is possible with restraints being readily and continuously incorporated into the solution.

An example of (c) is provided by the simple extension of the process to short-circuit studies in which the difference

SE 20090 LOAD FLOW 400 MVA BASE

RUN 3.9

NET MW	NET MVAR	V PU	A DEG	BUS
44				
-.00090 +.00930	-.38	-.22	.9991	.53	1
+.04474 +.00780	-.03	-.00	1.0448	.43	2
+.00039 +.02246	-.23	.54	1.0006	1.29	3
+.01118 +.02151	-.01	.00	1.0114	1.22	4
+.01385 +.09366	-.27	.04	1.0182	5.28	5
-.00705 +.02665	-.36	.10	.9933	1.54	6
-.01175 +.08319	.05	.06	.9917	4.81	7
-.00752 +.05929	.05	.05	.9942	3.42	8
-.01686 +.14961	-.11	.14	.9945	8.66	9
-.02225 +.22323	-.15	.20	1.0029	12.86	10
-.00167 +.22399	-.06	.20	1.0231	12.65	11
-.05575 +.30202	-.02	.00	.9914	17.73	12
-.06932 +.35159	-.02	-.01	.9949	20.69	13

SEND MW	SEND MVAR	RECEIVE MW	RECEIVE MVAR	I PU	A DEG	BRANCH
83.98	-15.46	83.32	-22.81	.215	28.16	1
1.55	-12.25	1.53	-12.50	.031	95.66	2
160.10	-36.40	157.78	-60.12	.413	33.50	3
71.50	-12.74	69.78	-17.80	.181	22.95	4
159.26	-5.34	156.49	-25.59	.389	14.57	5
25.06	-6.51	24.50	-8.15	.065	23.20	6
32.29	-9.42	31.29	-12.33	.085	24.91	7
19.44	-6.53	19.06	-7.64	.052	23.38	8
13.02	-3.67	12.88	-4.09	.034	19.17	9
21.38	-9.52	21.34	-9.95	.059	25.52	10
-.03	33.00	-.08	31.56	.079	-89.62	11
156.22	40.88	154.40	29.09	.396	-9.39	12
-.01	42.52	-.06	42.07	.105	-88.80	13
-12.40	3.24	-12.42	3.12	.032	-165.37	14
27.84	-1.06	27.78	-1.42	.070	3.47	15
-10.23	1.46	-10.27	1.23	.026	-171.88	16

REF GEN MW	REF GEN MVAR
134.37	102.69

2 *Reproduction of load-flow study output*

3 *Reproduction of short-circuit study output*

SE 20090 S/C STUDY 400 MVA BASE

RUN 3.9

BUS 11 1121 MVA 17 ITERATIONS

BRANCH	I PU	A DEG
2	.584	-69.23
3	1.293	-56.65
5	1.008	-87.60
GEN.	.000	.00

BUS 5 1079 MVA 14 ITERATIONS

BRANCH	I PU	A DEG
5	1.119	-58.77
12	1.648	-85.10
GEN.	.000	.00

voltages are replaced by busbar voltages to neutral V and the nodal-admittance matrix is modified for constant shunt impedances to become Y'. The network driving functions are the pre-fault voltages E_g behind appropriate generator admittances y_g, these voltages being automatically determined from the pre-fault load-flow condition.

The resulting equations:

$$Y'V = y_g E_g$$

are solved by the modified Gauss–Seidel process with the voltage of a selected busbar continuously restrained to zero, corresponding to a short-circuit at that location. The application of simultaneous short-circuits or the inclusion of such effects as those of voltage regulators is particularly simple by this method.

Sample studies

Fig. 1 is a circuit diagram of a typical 16-busbar system, showing the method of network definition. Fig. 2 is a reproduction of the computer output for a load-flow study, illustrating the ease of interpretation of study results that can be achieved by the development of a special output subroutine.

Fig. 3 is a reproduction of the computer output for a short-circuit study following the load flow of Fig. 2 for faults applied separately at busbars B_{11} and B_5.

The times for these studies have no meaning unless related to the characteristics of the computer used, and this is covered in detail in the paper. 681.142: 621.316.11

A.F. amplifier for precise voltage measurement

This short article by S. Harkness, Graduate, and F. J. Wilkins, B.A., B.Sc., is based on a Measurement and Control Section paper (3335) 'The design of an audio-frequency amplifier for high-precision voltage measurement'. The paper was published individually in October 1960 and will be republished in Part B of the Proceedings. It was read before the Section on the 10th January 1961 at Savoy Place (see p. 195). The authors are at the National Physical Laboratory.

The following papers were read at the same meeting: paper 3159 'Improvements in the precision measurement of capacitance' by G. H. Rayner and L. H. Ford (see p. 171); paper 3296 'The design and performance of high-precision audio-frequency current transformers' by J. J. Hill and A. P. Miller; and paper 3297 'Techniques for the calibration of standard current transformers up to 20kc/s' by J. J. Hill (see p. 169).

THE amplifier described in the paper is designed as an accessory to the electrostatic voltmeters which are used as a.c.–d.c. transfer instruments at the N.P.L. The transfer error of these instruments is believed to be not more than 1 part in 10^4 at frequencies up to 100kc/s.

Range of instruments

Most of the instruments are designed to be used in the range 65–115 volts and have a reading accuracy within at least 1 part in 10^4 in this range. Lower voltages can therefore be measured to this degree of accuracy only if they are first amplified. Transformers have been used for many years for this purpose at power frequencies.

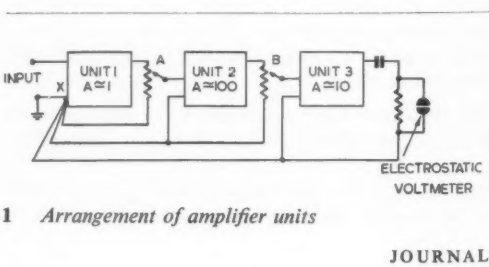
However, the design of transformers of high ratios to cover a wide frequency range is difficult. Their comparatively low impedance is also frequently a source of error, e.g. in determining current by the measurement of the voltage developed across a known standard resistor. The electronic amplifier which has been developed has improved performance with respect to input impedance, sensitivity and frequency response, and has a predictable, although inferior, long-term performance.

It is seen from Fig. 1 that the amplifier consists of three cascaded amplifier units with tapped dividers at A and B to control the over-all gain. Gain changes giving multiplying factors of 2, 10, 20, 100, 200 and 1000 are effected at A, and factors of 0·3, 0·5, 0·75 and 1 are given by the control at B. Thus a large number of gains are possible in steps whose ratio is not more than about 1·6 : 1, thereby enabling any voltage between 60mV and 60 volts to be measured by reading the electrostatic voltmeter in the most sensitive part of its range.

The initial unit acts simply as an impedance transfer and raises the input resistance to about 50 megohms. All three units are based on a feedback circuit shown in Fig. 2, which is commonly called a 'ring of three', the various gains being realized by varying the feedback factor $R_k/(R_f+R_k)$. In units 1 and 2 the feedback resistors (R_f, R_k) have additional tappings and form the dividers A and B respectively.

Performance of amplifier

To check the performance of the amplifier, a divider bearing the inverse ratio to the amplifier gain is used to precede the



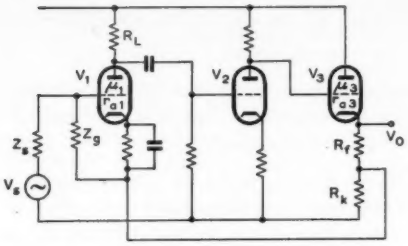
1 *Arrangement of amplifier units*

amplifier. The supply and output voltages are then either displayed simultaneously on two voltmeters or, when supplies are sufficiently steady as when electronically generated supplies are used, displayed alternately on the same voltmeter. A set of three calibrating dividers enables all ranges to be checked.

For ease of working and particularly to ensure confidence in the instrument, it was considered essential to reduce to a minimum the number of calibrations required. Accordingly, heating changes, as distinct from ageing effects, have been reduced to about 1 part in 10^4 per working period of 8 hours; and, to an accuracy within 1 part in 10^4, the amplifiers, within most of the frequency band 30c/s–30kc/s, have been made independent of frequency, output-voltage level and gain position.

This performance has been achieved by careful consideration of the sources of error in a conventional circuit rather than by elaborate techniques, and there has been careful choice of components, lay-out, etc. In particular, the availability of resistance alloys of high resistivity, low temperature coefficient and good stability, such as Karma and Evanohm, has been of great importance, for without them this performance could not have been attained with the present design.

621.317.32:621.375.13



2 *Basic amplifier circuit*

DESIGN, PERFORMANCE AND CALIBRATION OF HIGH-PRECISION AUDIO-FREQUENCY CURRENT TRANSFORMERS

A short article based on two Measurement and Control Section papers: paper 3296 'The design and performance of high-precision audio-frequency current transformers' by J. J. Hill, B.Sc., Associate Member, and A. P. Miller; and paper 3297 'Techniques for the calibration of standard current transformers up to 20kc/s' by J. J. Hill. The papers were both published individually in September 1960 and will be republished in Part B of the Proceedings. They were read on the 10th January 1961 before the Section at Savoy Place (see p. 195). The authors are at the National Physical Laboratory.

The following papers were read at the same meeting: paper 3159 'Improvements in the precision measurement of capacitance' by G. H. Rayner and L. H. Ford (see p. 171); and paper 3335 'The design of an audio-frequency amplifier for high-precision voltage measurement' by S. Harkness and F. J. Wilkins (see p. 168).

During the past few years, a large number of toroidally-wound audio-frequency current transformers have been submitted to the N.P.L. for test at frequencies ranging from 400c/s to 10kc/s. Most of these transformers were found to have large errors which were very dependent on the relative potentials of the primary and secondary circuits; many required prohibitively high values of primary voltage to supply them; while others developed high internal temperatures, with rapidly changing errors. This unsatisfactory state of affairs led to a theoretical and practical examination of the design aspects of precision a.f. current transformers being undertaken by the Laboratory.

Capacitance effects

When the usual textbook theory is extended to include the effects of capacitance, it can be seen that the h.f. performance

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1 *Current transformer*
Current ratios 5/5, 10/5, and 20/5amp

is dependent, among other factors, on:

1. The distribution of the capacitances between the windings
2. The value of the product of the total leakage reactance and the total inter-winding admittance.

It can then be shown that the performance is improved if the inter-winding capacitance is symmetrically and uniformly distributed. The error due to the product referred to in (2) changes in a complicated manner as the thickness of the insulation space between the windings is varied. As this thickness is progressively increased from zero, the error at first decreases rapidly to a minimum and then increases slowly again.

In most precision transformers of conventional design, the secondary turns occupy several layers wound directly one over the other, and frequently the primary winding also has more than one layer. This form of construction concentrates most of the inter-winding capacitance between one primary and one secondary terminal, and this leads to unsatisfactory h.f. performance.

To conserve winding space and, to a certain extent, to avoid undue increase in the leakage inductances, the insulation space is frequently reduced to a minimum, with consequent adverse effects on the performance. In any event, the leakage inductances are often already too great, owing to the relatively large radial depth of these multilayer windings. Finally, the increase in resistance of the windings with frequency, owing to skin and proximity effects, is a function of the number of layers.

Single-layer construction

While reasonably satisfactory capacitance distributions can be obtained using special winding techniques, these usually present practical difficulties; and, where high accuracy at high audio frequencies is essential, multilayer windings should be abandoned in favour of a single-layer form of construction.

When the turns of a primary and secondary winding are distributed uniformly around a ring-shaped core, each in a single layer, the capacitance distribution between these windings closely approaches the ideal, and extremely low values of leakage inductance are obtained. If more than one primary to secondary ratio is required, the single primary winding should be divided into the appropriate number of equal sections and means provided for connecting them in series and parallel combinations.

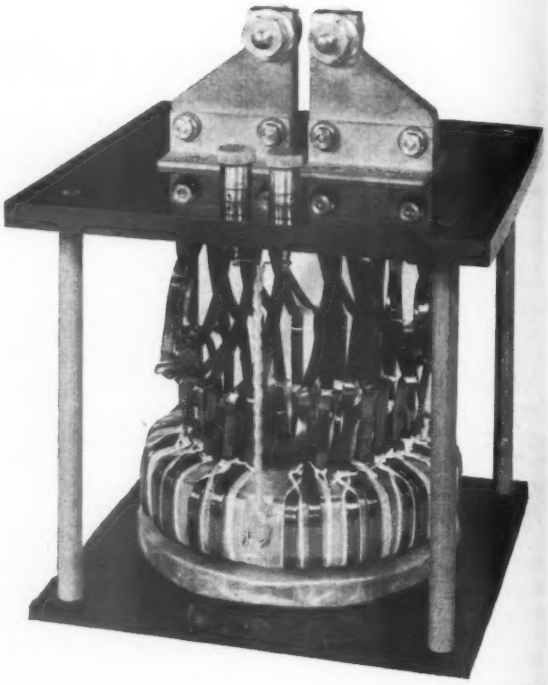
The limitation on the number of turns that can be wound in a single layer on a given core could, however, adversely affect the l.f. errors of a transformer intended for operation over a wide frequency band. This can be avoided by using the thin-strip, low-loss, nickel–iron alloy core materials which are now available with initial d.c. permeabilities in excess of 40000.

Several precision multi-ratio transformers based on the foregoing design considerations have recently been constructed by the N.P.L. Covering rated primary currents between 5 and 400amp, their errors throughout their designed frequency range (400c/s–10kc/s) do not exceed 5 parts in 10^5 in magnitude and 0·3′ in phase. Over the extended range from 50c/s to 30kc/s, the errors are less than 2 parts in 10^4 and 1′. Two of these transformers are shown in Figs. 1 and 2.

Calibration

The calibration of a standard current transformer is usually done by the null-bridge method, which uses standard 4-terminal non-inductive resistors connected in series with the primary and secondary circuits. At high audio-frequencies, many precautions have to be taken if errors due to unwanted inductive couplings in the circuits are to be eliminated from the measurements.

In view of their bulk and high power dissipation, the heavy-current standard resistors are rarely fitted with electromagnetic shields, and moreover their resistance and time-constant values are frequency-dependent.



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2 *Current transformer*

Current ratios 200/5 and 400/5amp

The techniques whereby all the errors are virtually eliminated are somewhat complicated. It can be stated, however, that they have now made it possible to reduce the uncertainties in the calibration of a precision current transformer to 5 parts in 10^5 and 0·1′ at 20kc/s and to half these amounts at 10kc/s and below.

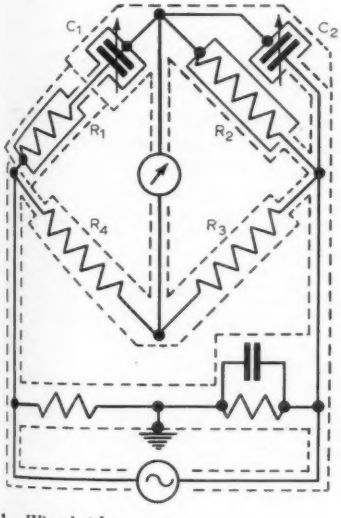
621.314.224
621.317.313:621.314.224

Capacitance measurement

A brief note based on a Measurement and Control Section paper (3159) 'Improvements in the precision measurement of capacitance' by G. H. Rayner, B.A., and L. H. Ford, M.Sc., Associate Members. The paper was published in Part B of the Proceedings, Vol. 107, p. 185. It was read before the Section at Savoy Place on the 10th January 1961 and a report of the meeting appears on p. 195. The authors are at the National Physical Laboratory.

The following papers were read at the same meeting: paper 3335 'The design of an audio-frequency amplifier for high-precision voltage measurement' by S. Harkness and F. J. Wilkins (see p. 168); paper 3296 'The design and performance of high-precision audio-frequency current transformers' by J. J. Hill and A. P. Miller; and paper 3297 'Techniques for the calibration of standard current transformers up to 20kc/s' by J. J. Hill (see p. 169).

A WIEN bridge, the circuit diagram of which is shown in Fig. 1, relates resistance, capacitance and frequency, the simple equation of balance being $\omega^2 C_1 C_2 R_1 R_2 = 1$. Since both resistance and frequency are quantities which are accurately known in most laboratories, the bridge provides a convenient method of measuring capacitance. A measurement of the ratio of the capacitances C_1 and C_2 is also required to obtain their individual values, as only their product is given by the normal Wien-bridge balance.

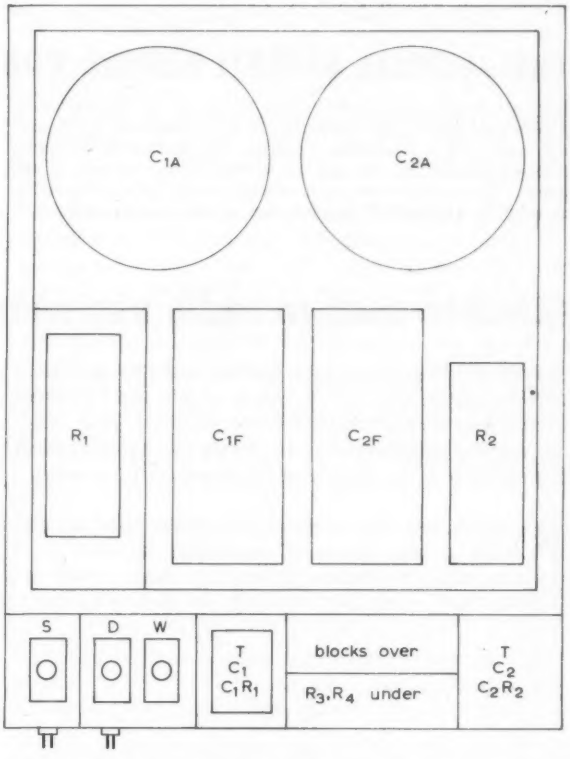


1 *Wien bridge*

Calibration by Wien bridge

The Wien bridge which has been made recently at the National Physical Laboratory may be regarded as an instrument for calibrating the working standards of capacitance, and it was designed to perform this function to the highest attainable accuracy at a single frequency, 1 kc/s. The approximate values of the components are $C_1 = 0{\cdot}8\,\mu F$, $R_1 = 200$ ohms, $C_2 = 0{\cdot}4\,\mu F$ and $R_2 = 400$ ohms.

The lay-out, which has been made as compact as possible, is shown in Fig. 2. The terminals T in compartments near the front edge enable the capacitors C_1 and C_2 and the resistors R_1 and R_2 to be compared with the appropriate working standards; all the necessary changes of connection are made by inserting plugs in blocks in the compartment between these terminals.



2 *Lay-out of components (to scale)*
S, D, W source, detector and Wagner switches
T terminals
over-all dimensions: 14in. × 11in. × 8in. high

In use, the Wien bridge is first balanced by adjusting the small variable air capacitors C_{1A} and C_{2A}. The total capacitances in arms 1 and 2 are then compared with the appropriate sections of an adjustable standard capacitor covering the range $0{\cdot}1$–$1{\cdot}0\,\mu F$ on a Schering bridge. Finally the sections of this capacitor are compared with one another on the same bridge. These three sets of observations are sufficient to provide a complete calibration of the standard capacitor, in terms of the resistance and frequency standards of the N.P.L.

Papers read (continued)

Comparison with Astbury bridge

Hitherto the unit of capacitance has been established at the N.P.L. in terms of mutual inductance and resistance by the Astbury bridge, using a modified Carey Foster network. Six determinations made as nearly as possible simultaneously on both Astbury and Wien bridges have shown a mean difference of 2 parts in 10^6 in the unit as established by the two bridges. The Wien bridge is regarded as probably the more accurate because it was designed to make a single measurement with the highest precision, whereas the Astbury bridge was designed to cover a wide range of measurements of both capacitance and inductance. 621.317.335

THE JOURNAL DIGEST: PAPERS PUBLISHED

In this monthly section are articles based on, or summaries of, papers published in the *Proceedings* of The Institution which have not been read at Institution meetings. The articles are on topics of some general interest and are written by the authors of the papers. The authors have been asked to make the articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics covered. The contents of the articles develop the main points and conclusions of the papers, although their subject-matter is not necessarily confined to that of the original papers. The summaries are included primarily for reference. Reprints, price 2s., become available about two months after publication

Circuits used in radio astronomy

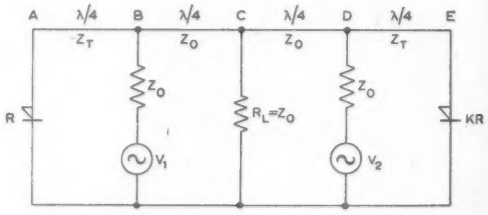
A brief article based on an Electronics and Communications Section paper (3471) 'R.F. switching circuits and hybrid-ring circuits used in radio astronomy' by F. G. Smith, M.A., Ph.D. The paper is published this month in Part B of the Proceedings. The author is at the Mullard Radio Astronomy Observatory.

RECEIVERS used with practically all types of radio telescope attain a high degree of sensitivity and stability by recording either a difference between two signal sources or a correlation between them. Both techniques avoid the direct recording of receiver noise, and both can use a variety of switching and hybrid circuits.

1 *Series changeover switch*

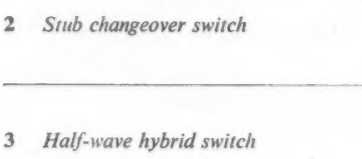
At frequencies where coaxial circuits are appropriate, the simplest switching element is the crystal diode, which can be biased 'on' or 'off' to provide an impedance low or high compared with the characteristic impedance of the coaxial line. The loss introduced by the switch may be minimized by the use of coaxial transformers between the crystal diodes and the rest of the circuit.

The maximum power transmission in a simple changeover switch at a frequency f is represented by $(1 - 2f/f_0)$, where f_0 is a frequency which is characteristic of the crystal diode. If the diode in the forward-biased condition is effectively a low resistance R, and in the back-biased condition is effectively a small capacitance C, then f_0 is $1/2\pi CR$; this is sometimes referred to as the cut-off frequency for the diode, and it may be of the order of 100 Gc/s.



2 *Stub changeover switch*

3 *Half-wave hybrid switch*



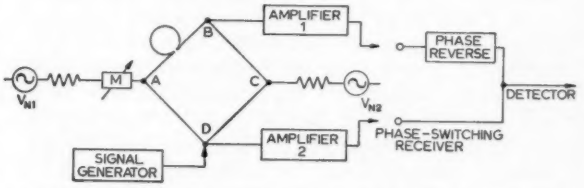
Changeover switches

Changeover switches may use either a series or a stub connection, as in Figs. 1 and 2. In both, the transformer sections necessary to obtain least loss are shown, but not the d.c. connections to provide bias. For the least loss it is also necessary to provide a shunt inductance across the diode, so that the capacitance C is tuned out in the 'off' position. The stub arrangement seems to be the most suitable way of achieving both this short tuning and the d.c. connection, particularly at higher frequencies.

Two changeover switches may be combined to make a phase-changing switch for the insertion of an extra length of coaxial line. In Fig. 3 the particular case of a phase-reversing switch is shown. The circuit is now a particular form of the 180° hybrid ring. The series loss is twice that of a simple changeover switch. Whatever the loss, this circuit provides an exact phase reversal at the centre frequency.

Hybrid circuits

Hybrid circuits are also used in radio astronomy as power splitters and for impedance comparison. Fig. 4 shows the circuit used recently by Costain* for the comparison of small noise powers, in which the hybrid circuit was used in both these ways in turn. The two amplifiers 1 and 2 ideally receive noise signals $V_{N1} - V_{N2}$ and $V_{N1} + V_{N2}$, respectively, from the 180° hybrid ring ABCD. The receiver output, after these have been added via a commutating 180° switch and after a simple square-law detection, is proportional to $V_{N1}^2 - V_{N2}^2$.



4 *Comparison of noise powers, using a phase-switching receiver*

It is, however, important to check the impedance of noise sources when their power is small compared to that of the receiver noise. This is done by disconnecting amplifier 2 from point D and feeding in an r.f. signal at this point from a high-level signal generator. Any inequality of impedance will allow some of this signal to enter the receiver via amplifier 2, so that a matching network M may be adjusted for zero transmission.

The hybrid ring is one of a class of directional-coupler circuits, and other forms can be used in a similar way.

621.318.57: 621.396.946

* Costain, C. H.: *Monthly Notices of the Royal Astronomical Society*, 1960, 120, p. 248

International microwave radio-relay systems

A short article based on an Electronics and Communications Section paper (3412) of the 'integrating' type 'The standardization of international microwave radio-relay systems' by W. J. Bray, M.Sc.(Eng.), Member. The paper is published this month in Part B of the Proceedings. The author is in the Post Office Engineering Department.

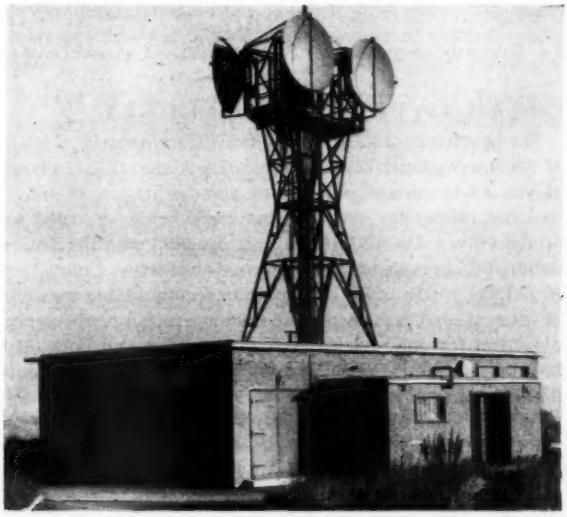
The microwave radio-relay systems described in the paper operate at frequencies above about 1000 Mc/s and are of two types:

(i) Systems using line-of-sight, or nearly line-of-sight, paths

(ii) Systems employing the tropospheric-scatter mode of propagation with paths extending well beyond the visible horizon.

Radio-relay systems using line-of-sight paths of up to 80 km between repeater stations (see Fig. 1) are already well established in many countries as part of the national trunk network for multi-channel telephony and television. When interconnected with similar systems or with line systems in other countries, they become part of the international trunk network. Such radio-relay systems may provide, on each radio carrier, up to 2000 telephone channels or a television channel with or without some hundreds of telephone channels, and a number of radio carriers may be provided over a given route.

Large-capacity radio-relay systems are used mainly in



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1 *Microwave line-of-sight radio-relay station*

Papers published (continued)

countries with highly developed communication systems; however, low-capacity systems are often used in countries with smaller communication requirements, and as spurs to large-capacity systems. Thus line-of-sight radio-relay systems covering a wide range of capacities are needed. The international standardization of such systems is well advanced.

Radio-relay systems using the tropospheric-scatter mode of propagation have so far found application only on a limited scale. Nevertheless, they are useful for the provision of links up to some 500 km long in a single hop over stretches of water or difficult terrain, in conditions where line-of-sight radio-relay links or coaxial-cable links are impracticable or uneconomic. Capacities of up to 100 or so telephone channels, or a television channel of moderate quality, can be provided on each radio carrier on links up to 300 km long; longer links are possible with smaller numbers of telephone channels. Because tropospheric-scatter systems are a comparatively recent development, international standardization has not reached an advanced state.

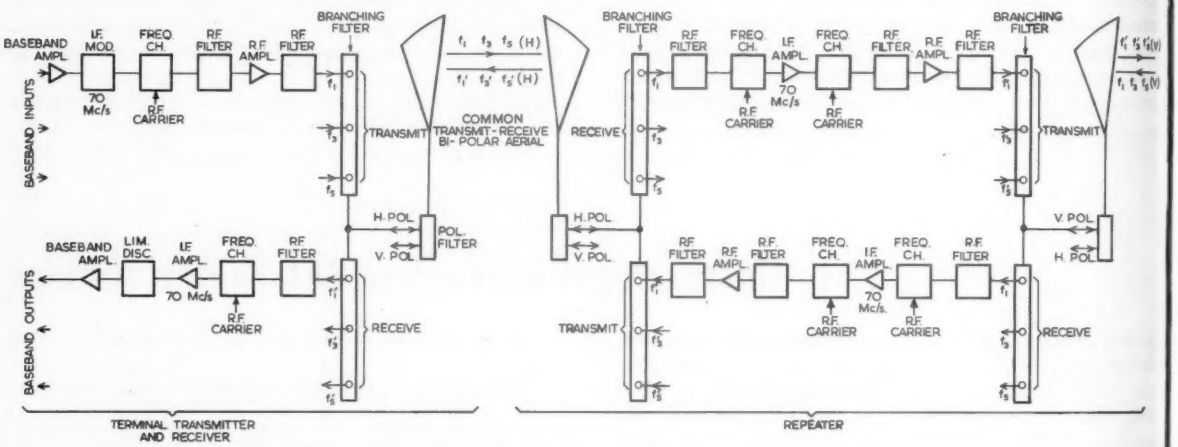
signals; another is the Joint Study Group for the Transmission of Television (C.M.T.T.), formed to study the problems of the transmission of television signals by line and radio-relay systems.

Typical multi-r.f.-channel radio-relay system

The general arrangement of a typical multi-r.f.-channel radio-relay system, shown in Fig. 2, is applicable primarily to line-of-sight systems, but certain of the features apply to other systems, such as those involving tropospheric-scatter propagation.

Most of the line-of-sight systems used for international circuits employ frequency modulation of the r.f. and i.f. carriers. Where several baseband signals, each comprising a block of frequency-division-multiplex (f.d.m.) telephony circuits or a television channel, are to be transmitted over the same route, considerable economy can be achieved by using the same aerials and feeders to transmit and receive a number of r.f. carriers on different frequencies (Fig. 2).

It is often convenient first to generate the f.m. carrier at an



2 *Schematic arrangement of typical multi-r.f.-channel radio-relay system*

Parts played by the C.C.I.R. and the C.C.I.T.T.

The International Radio Consultative Committee (C.C.I.R.) of the International Telecommunication Union (I.T.U.) have played an important part in the standardization of international radio-relay systems, this work being entrusted to Study Group IX of the C.C.I.R. In addition, the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.) have made it possible to secure a large measure of international agreement on common over-all performance objectives for radio-relay and line systems, so that both may be integrated on an equal footing into the general trunk network.

Special joint working or study groups comprising both line and radio-system experts have been set up to study certain problems. One such group is the C.C.I.T.T./C.C.I.R. Joint Working Party on Circuit Noise, appointed to determine the permissible levels of circuit noise in radio-relay and line systems for the transmission of telephone and telegraph

intermediate frequency, generally centred on 70 Mc/s, and then to shift the frequency to the desired radio frequency by mixing with a r.f. carrier of good stability. After selection in r.f. filters and amplification to a power of a few watts, the r.f. signals from a number of transmit channels can be combined in a branching filter and applied via a common feeder to a wideband aerial. The wideband aerial may, if desired, function simultaneously for reception and transmission.

On the receiving side, the r.f. signals are separated by r.f. filters, frequency-changed to an intermediate frequency generally centred on 70 Mc/s, and amplified to a suitable level for limiting. The limited signal is applied to a linear discriminator, the output of which is the desired baseband signal.

Other facilities which may be provided are automatic frequency control of the transmitted and received carrier frequencies and automatic gain control prior to limiting.

The schematic arrangement of a typical multi-r.f.-channel repeater of the non-demodulating type is also shown in

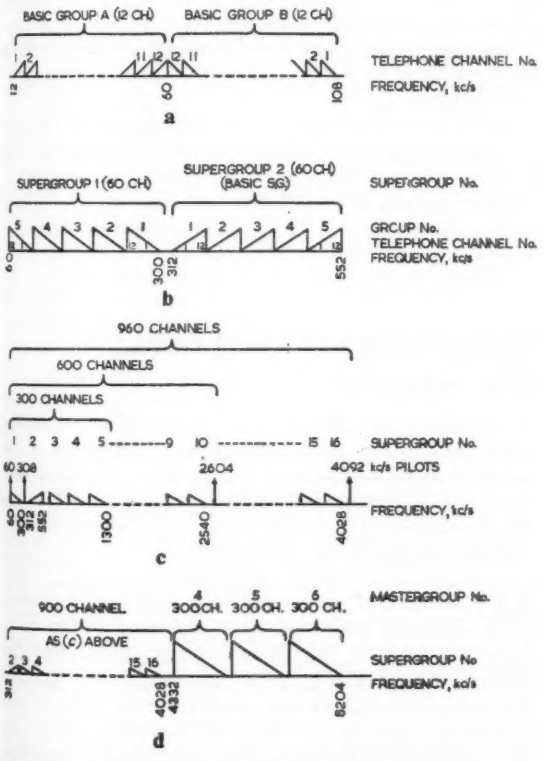
Fig. 2; that shown involves frequency-changing from a radio frequency to an intermediate frequency, also generally centred on 70 Mc/s, and back to a different radio frequency. Other forms of repeater are sometimes used in which the change of radio frequency is effected directly without the use of an intermediate frequency.

Economically, it is desirable to keep the total equipment provision to a minimum by sharing, whenever possible, common equipment between several broadband channels. Too much common equipment, however, may reduce the over-all reliability below an acceptable standard or give rise to design difficulties leading to inferior performance.

The achievement of adequate reliability generally necessitates a protection broadband channel which can be manually or automatically switched into service if a working broadband channel fails, e.g. owing to propagation or equipment failures. Up to five working channels can share the same protection channel and still achieve adequate reliability.

Multi-channel telephony systems

Most line systems for multi-channel telephony use f.d.m., the signal in each telephone channel being of single-sideband suppressed-carrier form. The channel spacing, 4 kc/s, and the basis of combining telephone channels in groups (12 channels), supergroups (60 channels), and mastergroups (300 channels) have been standardized by the C.C.I.T.T. Typical arrangements are shown in Fig. 3.



3 *Typical arrangements of f.d.m. telephony channels*

a 12- and 24-channel systems
b 60- and 120-channel systems
c 300-, 600- and 960-channel systems
d 1800-channel system

A great deal of line plant in the form of 12-, 24-, 48- and 60-circuit carrier systems and 600- and 960-circuit coaxial-cable systems using the standard C.C.I.T.T. f.d.m. arrangements of channels has been brought into use in many countries during the past three decades. It has been natural, therefore, to develop multi-channel radio-relay systems on the same f.d.m. channelling basis as line systems, since this permits interconnection of line and radio-relay systems at the group, supergroup or mastergroup levels, without the need to translate channels to audio frequency.

It also permits blocks of circuits to be readily switched, e.g. in the event of breakdown, from line to radio-relay systems or vice versa and enables the same type of translating equipment to be used for both types of system.

Television systems

The long-distance transmission of television signals over coaxial-cable systems requires the translation of the signal from video frequency to a frequency band above a few hundred kilocycles per second in order to avoid l.f. interference and to simplify repeater design. The signal transmitted by the cable consists of an asymmetric-sideband signal with a video carrier which may be of reduced level.

On the other hand, radio-relay systems transmit television signals most efficiently when the video signal, with or without pre-emphasis, modulates the radio carrier directly. Thus interconnection between radio-relay and coaxial-cable systems is generally carried out at video frequency, using agreed video levels and transmission bandwidths at the point of interconnection.

Characteristics agreed internationally

The basic characteristics of line-of-sight microwave radio-relay systems, most of which have been agreed internationally, are:

(i) the over-all transmission performance for telephony (including music circuits), television and telegraphy (including data transmission)
(ii) the baseband characteristics
(iii) the i.f. characteristics
(iv) the modulation characteristics of the r.f. carriers
(v) the r.f. characteristics, including the frequency patterns of the channels in multi-r.f.-channel systems
(vi) the characteristics of the supervisory, control and monitoring systems needed for maintenance purposes.

Line-of-sight systems suitable for 24-, 60-, 120-, 300-, 600-, 960- and 1800-telephone channels using f.d.m. channelling arrangements shown in Fig. 3, and for television using the 405-, 525-, 625- and 819-line standards, have been defined, together with the appropriate pre-emphasis and de-emphasis characteristics. In 1800-telephone-channel systems, provision has been made for the alternative transmission of television and multi-channel telephony on the same radio carrier.

Papers published (continued)

R.F.-channel arrangements in the 2000, 4000, 6000 and 7000 Mc/s bands have been agreed for line-of-sight systems of various capacities; these arrangements accommodate up to eight transmit and eight receive r.f. channels in each band.

Conclusions

While the international standardization of line-of-sight microwave systems has reached an advanced state, much remains to be done in tropospheric-scatter systems. Studies are in hand to determine the performance achievable in tropospheric-scatter systems, the maximum transmission capacity that is practicable, the modulation methods and characteristics to be used, and the r.f.-channel arrangements to be employed.

The work accomplished in line-of-sight systems has proved of considerable value, both to administrations in setting up national and international links and to manufacturers.

621.396.65

Phase variation of v.l.f. waves

A summary of an Electronics and Communications Section paper (3456) 'The phase variation of very-low-frequency waves propagated over long distances' by B. G. Pressey, Ph.D., Member, G. E. Ashwell, B.Sc., and J. Hargreaves, M.Sc. The paper is published this month in Part B of the Proceedings. The authors are at the Radio Research Station, British Department of Scientific and Industrial Research.

THE proposed use of v.l.f. waves (10–20 kc/s) for navigational aids of the phase-comparison type has led to the study of the phase variations of these waves when propagated over distances up to 6000 km. The particular aspect of this study described by the authors is the relative phase variations over a pair of adjacent paths.

Measurements have been made of the variations in the phase difference between the signals received from a single transmitter at two spaced receiving stations. The two principal transmitters used were at Varberg, Sweden, on a frequency of 17·2 kc/s and at a range of 1000 km, and at Annapolis, United States, on 15·5 kc/s at a range of 6000 km.

Receiver baselines, up to 280 km in length, were situated in England and oriented both transverse to, and along, the direction of propagation.

The observations were made at various seasons, and the results show the extent of the systematic diurnal changes and the random fluctuations: the former were of the order of 30° at the shorter range and 5° at the longer, and the latter had standard deviations at both ranges of the order of 4° in the daytime and 10° at night.

The magnitude of the random phase fluctuations can be calculated from measurements of the corresponding amplitude fluctuations. In this way, data on phase fluctuations at night at intermediate ranges and for receiver spacings up to 2000 km have been obtained. The relation between the receiver separation and the correlation between fluctuations on two paths has been examined, and the authors show how the results of the phase measurements may be applied to other receiver arrangements.

621.391.812 : 621.317.77

Coaxial-connector system

A summary of an Electronics and Communications Section paper (3499) 'A coaxial-connector system for precision r.f. measuring instruments and standards' by D. Woods, Associate Member. The paper is published this month in Part B of the Proceedings. The author is at the British Ministry of Aviation.

GENERAL design requirements are discussed for a coaxial-connector system for precise r.f. impedance and admittance standards, bridges and measuring instruments of all types for frequencies up to 4 Gc/s.

A description is given of a practical connector system that has been in use for many years at a Ministry of Aviation laboratory.

The design is such that the connector system does not introduce uncertainties greater than about 3 parts in 10^4 in the admittance parameter.

The residual parameters of the connector system, including the open-circuit and short-circuit conditions, are described and evaluated.

Data relating to the discontinuity capacitances encountered in a practical measuring system are also given, together with formulae for the precise transformation of admittance between two planes in a uniform coaxial line.

621.317.7.029.63 : 621.315.212.2

Measurement of the Q-factor of a resonator

A summary of an Electronics and Communications Section paper (3502) 'The effects of parasitic modulation on the accuracy of measurement of the Q-factor of a resonator' by F. H. James. The paper will be published in Part B of the Proceedings. The author is at the Linear Accelerator Laboratories, Manchester University.

WHEN the Q-factor of a resonator is determined by using sinusoidal amplitude modulation and measuring the envelope phase shift, the presence of unwanted frequency or phase modulation may reduce the accuracy of the result. The envelope phase shift depends on the ratio of the parasitic-modulation index to the amplitude-modulation index, and on the phase angle between the two modulation components. If measurements are made with the carrier set as close as possible to the resonant frequency of the resonator, increased frequency stability is required.

Alternatively, if advantage is taken of an approximation

to exact tuning, which is given by setting the carrier so that the envelope phase shift is a maximum, a systematic error is introduced. If the ratio of the modulation indices or the phase relation between the modulation components is known, the systematic error may be determined and a correction applied to the result. If either of two special phase relations can be set up between the modulation components, the parasitic modulation can be rendered innocuous; in these conditions, as high an order of accuracy can be achieved as if pure amplitude modulation were used. 621.372.413 : 621.376

THE JOURNAL DIGEST: PAPERS TO BE READ

Papers accepted for reading at meetings and eventual publication in the Proceedings of The Institution are first published individually. The separate papers are supplied free of charge, and as soon as they become available they are summarized in this feature.

Those who obtain a copy of a paper published individually are urged—if they do not take the Part of the Proceedings in which it will be republished—to apply in due course for a reprint, as this is the final and correct version and includes the discussion. Reprints become available, price 2s., about two months after the appearance of the paper in the Proceedings.

Applications quoting the serial number of the paper or reprint as well as the author's name, and accompanied by a remittance where appropriate, should be addressed to the Secretary of The Institution. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Technical and economic aspects of the supply of reactive power in England and Wales *Paper* 3528S, *Part A*

W. CASSON *and* H. J. SHEPPARD, B.SC.

THE authors discuss some problems of supplying reactive power in the transmission and distribution systems of England and Wales.

The over-all reactive-power requirements of the inductive loads of consumers, and the shunt and series inductances of the system, are reviewed, and their effect on generator characteristics is examined. Consideration is given to the problems of supplying the demand for reactive power by means of the generators, system capacitance and compensating devices, and a scheme is outlined for the effective control of reactive power and voltage. An example is given relating to the possible conditions when the system load reaches 30GW, and it is shown that the kVAr/kW ratio at bulk-supply points for the optimum loading of the generators postulated is about 0·4 (0·93 lagging power factor) at times of peak load.

Estimates are made of the extra cost of providing and operating a power-supply system to transmit reactive as well as active power. Consideration is given to various forms of tariff adjustment for reactive-power supply, leading to a preference for separate charges for active- and reactive-power demands.

The advantages and disadvantages of generating reactive power at or near the load, by the consumer or by the supply authority, are discussed.

Present methods of tariff adjustment are generally effective in inducing consumers to limit their demands for reactive power to an extent which would make uneconomic the provision of additional sources of reactive power on distribution systems.

To be read on the 6th April 1961

The concept of equivalent source e.m.f. and equivalent available power in signal-generator calibration *Paper* 3356M, *Part B*

D. WOODS

THE source impedance of a signal generator for use in terminated conditions has a direct effect on the accuracy of the load voltage. Signal-generator specifications rarely give detailed information about the variation of this parameter with frequency. Consequently, the user is generally forced to assume that it is constant and equal to the nominal value. The view is maintained that it is impracticable to apply corrections for this parameter, even if its value is known.

Three methods are analysed for calibrating the output level of signal generators, with a view to determining that method which minimizes the error in the load voltage due to source-impedance variation. The methods are each compared in terms of the voltage ratio produced across an arbitrary load impedance by an imperfect generator to a perfect generator. The voltage ratios are expressed in terms of the reflection coefficients of the generator and load impedances. The minimum and maximum of the ratios are given in terms of voltage standing-wave ratios. The results are equally applicable to coaxial and waveguide systems.

The recommended method employs the concept of equivalent source e.m.f. or equivalent available power. The requirements for a suitable instrument to measure these quantities are briefly discussed.

Recommendations are made regarding the manner of specifying the tolerances on signal-generator parameters which affect the accuracy of the load voltage, namely the calibration level, the attenuation and the source impedance.

To be read on the 11th April 1961. This paper was originally published in the January 1961 Proceedings, 108B, p. 37

The calculation of the magnetic field of rotating machines. Part 2—The field of turbogenerator end-windings *Paper* 3489S, *Part A*

D. S. ASHWORTH, B.A., *and* P. HAMMOND, M.A.

THE magnetic field of turbogenerator end-windings is analysed. Particular attention is paid to the field at the surface of the stator-core end-plate. The effects of varying the cone angle of the end-winding, the chording angle and the length of the axial portion of the end-winding are discussed. The effect of the power factor is considered with particular reference to the large fields observed at leading power factors. Experimental results on a model winding show reasonable agreement with the computed results.

To be read on the 12th April 1961

The magnetic field of the end-windings of turbogenerators *Paper* 3490S, *Part A*

P. J. LAWRENSON, M.SC.

AN investigation of the magnetic field generated by the currents in the stator end-windings of a 3-phase 2-pole turbogenerator is described. It includes an examination of the influence of winding design, namely the effects of cone angle, straight projection and coil pitch, of the influence of the air-gap, and also of the permeability, or eddy-current screening, of the core end-plate.

The simple and accurate method which is used to calculate the field of the stator currents, and which can be used for a circuit of any shape, is described. The effect of the air-gap is represented by

Papers to be read (continued)

a fictitious conductor, and the influence of the end-plate is accounted for by using the method of images. Results are presented for the magnitude and phase of the fundamental and harmonic waves of the rotating fields on the end-plate and rotor-coil retaining-ring surfaces.

From the results these points appear:

(i) The predominant loss-producing component of the field at the end-plate surface arises from the fringing at the end of the air-gap
(ii) In order to reduce loss-producing components of the field at the end-plate owing to the winding, the cone angle should be made small and the straight projection large
(iii) The use of a non-magnetic end-plate reduces the axial component of the field
(iv) The use of eddy-current screening, while eliminating the axial components, increases the radial components
(v) Near the winding and the air-gap, the field contains a high proportion of harmonic components which induce loss in the rotor-coil retaining ring and which increase in magnitude with increases in the straight projection of the winding and the air-gap magnetomotive force
(vi) Changes in coil pitch do not significantly influence either the fundamental or the harmonics of the end-field.

To be read on the 12th April 1961

Progress in oil-filled cables and their accessories *Paper* 3513s, *Part A*

A. N. ARMAN, PH.D., F. J. MIRANDA, DR.-ING., *and* G. R. BISHOP

AFTER recalling the genesis and growth of the oil-filled-cable system of power transmission and touching on the reliability as proved by 30 years of service experience, the authors dwell in detail on recent developments. Improvements in insulating and screening materials and in manufacturing techniques, particularly that of precise lapping, have warranted higher design stresses. The resulting increased consistency of performance has justified closer design limits. The importance is emphasized of balanced development of both a.c. and impulse performance of high-voltage cable and accessories.

Significant reductions in the dimensions of oil-filled-cable accessories have been effected without reduction in performance level, and the introduction of epoxy-resin castings has permitted a new approach to the design of certain of these accessories.

A development of considerable moment is the increase in permissible operating temperature, which gives oil-filled-cable systems overload capacity commensurate with that of the transformers with which they are frequently associated. Long-term investigations have shown that, with suitable materials and laying conditions, operation for very long periods at conductor temperatures up to 115°C is permissible.

To be read on the 19th April 1961

THE JOURNAL DIGEST: MONOGRAPHS

Monographs are first published individually, price 2s., and are republished later in Part C of the Proceedings of The Institution. As soon as the separate monographs are available, summaries are given in this feature.

Applications quoting the serial number of the monograph as well as the author's name, and accompanied by a remittance, should be addressed to the Secretary of The Institution.

For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

The surface-impedance concept and the structure of radio waves over real earth *Monograph* 434E

Z. GODZIŃSKI

THE concept of surface impedance as applied to the theory of radio-wave propagation over a real, i.e. inhomogeneous and irregular, earth is discussed; some of the conclusions may also be of value in the theory of waveguides, cavity resonators and certain types of aerial.

The advantages and limitations of the surface-impedance concept are shown in connection with a very general integral equation for the field strength.

The approximations and physical phenomena underlying the surface-impedance concept are first discussed in the simplest case of a homogeneous and flat earth. The analysis is extended to a horizontally stratified earth; it is then possible to characterize the earth by certain effective parameters depending on frequency and the geometric structure of the soil. The same is also true for a spherical, or not too excessively irregular, earth. The discussion is then generalized for an arbitrarily inhomogeneous earth. The height/gain function and the shape of the ellipse of polarization are discussed. Approximate boundary conditions for the Hertzian vector and Hertzian scalar function are related to the concept of surface impedance.

Practical conclusions are reached with regard to the existence and measurement of the effective earth constants and to some aspects of geological prospecting by radio methods.

The analysis of non-linear resonant circuits *Monograph* 435M

C. B. NEWPORT, PH.D., *and* D. A. BELL, M.A., PH.D.

THE authors describe two graphical methods of calculating the instantaneous voltages and currents that result from feeding a sinusoidal current to a resonant circuit which employs a non-linear inductor. The voltage-integral method uses a step-by-step approximation to the actual inductor characteristic, including hysteresis. Knowledge of the detailed waveforms facilitates the determination of the optimum magnitude and timing of a pulse to trigger a ferroresonant circuit from the dissonant to the resonant state. Calculated waveforms are satisfactorily confirmed experimentally.

Alternatively, the phase-plane method allows the use of a piecewise linear approximation to the magnetization characteristic of the core of the inductor (e.g. three straight lines), but at the cost of ignoring hysteresis.

Design of cylindrical surface waveguides with dielectric and magnetic coating *Monograph* 436E

T. BERCELI, DR.-ING.

THE author deals with wires whose coating has both dielectric and magnetic properties. Approximate formulae are given for the field concentration, propagation time, group velocity, power distribution, characteristic impedance, losses and maximum transmissible power.

The magnetic coat concentrates the field more strongly than does the dielectric one. The field concentration increases quickly with increase of permeability and hardly depends on permittivity.

The attenuation is due to the conductive, dielectric and magnetic losses of the guide. The dielectric loss depends also on permeability, and vice versa. The total loss of a given transmission line as a function of field concentration has a minimum, which can be achieved by a coating of appropriate thickness.

To determine the maximum transmissible power, two formulae can be used. One determines the maximum transmissible power from the highest permissible value of electric field strength, and the other from the highest permissible degree of overheating.

A description of design procedure for surface waveguides, illustrated by an example, is given.

THE JOURNAL DIGEST: IN THE *PROCEEDINGS*

The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (FEBRUARY 1961)

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PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (MARCH 1961)

Centre and Group Chairmen's Addresses

THE RT. HON. THE VISCOUNT CALDECOTE, D.S.C., M.A. PAPER 3516 **The future of electrics and electronics in aircraft** (Lecture) *April 1961*

E. H. COOKE-YARBOROUGH, M.A., *and* R. C. M. BARNES, B.SC.(ENG.). PAPER 3258M, JULY 1960 **Rapid methods for ascertaining whether the activity of a weak radioactive sample exceeds a predetermined level** *December 1960*

T. GLUCHAROFF, M.E. PAPER 3341M, NOVEMBER 1960 **Discrete analogue-computer compensation of sampled-data control systems** *March 1961*

W. J. BRAY, M.SC.(ENG.). PAPER 3412E **The standardization of international microwave radio-relay systems** *March 1961*

F. G. SMITH, M.A., PH.D. PAPER 3471E **R.F. switching circuits and hybrid-ring circuits used in radio astronomy** *March 1961*

D. WOODS. PAPER 3499E **A coaxial-connector system for precision r.f. measuring instruments and standards** *March 1961*

E. G. PRESSEY, PH.D., G. E. ASHWELL, B.SC., *and* J. HARGREAVES, M.SC. PAPER 3456E **The phase variation of very-low-frequency waves propagated over long distances** *March 1961*

E. M. CHERRY, M.SC. PAPER 3368E **Third-harmonic tuning of e.h.t. transformers** *January 1961*

R. A. WALDRON. Communication **Some remarks on waveguide modes**

Communicated discussion on **A correlator employing Hall multipliers applied to the analysis of vocoder control signals**

Communicated discussion on **Analysis of a frequency-modulated continuous-wave ranging system**

PART C. MONOGRAPHS (MARCH 1961)

Communicated discussion on **Extension of the dual-input describing-function technique to systems containing reactive non-linearity**

COLIN ADAMSON, M.SC.(ENG.), *and* M. VISESHAKUL, M.SC.TECH. 387S, JUNE 1960 **An analytical method for predicting the performance of semi-enclosed fuses** *June 1960*

R. F. HOSKINS, M.SC. 388E, JULY 1960 **Signal flow-graph analysis and feedback theory** *July 1960*

W. C. BAIN, M.A., B.SC., PH.D. 389E, JULY 1960 **The received-amplitude distribution produced by radio sources of random occurrence and phase** *July 1960*

P. GAZZANA-PRIAROGGIA, DR.-ING., E. OCCHINI, DR.-ING., *and* N. PALMIERI, DR.-ING. 390S, JULY 1960 **A brief review of the theory of paper lapping of a single-core high-voltage cable** *July 1960*

SHEILA AYERS. 391E, JULY 1960 **A new type of piezoelectric flexural vibrator in the form of balanced cantilevers** *July 1960*

F. G. HEATH, B.SC., *and* M. W. GRIBBLE, B.SC. 392M, JULY 1960 **Chain codes and their electronic applications** *July 1960*

A. S. ALDRED, M.SC., PH.D., *and* G. SHACKSHAFT, B.ENG., PH.D. 393S, JULY 1960 **Frequency response analysis of the stabilizing effect of a synchronous machine damper** *July 1960*

K. J. BINNS, B.SC. 394U, AUGUST 1960 **The magnetic field and centring force of displaced ventilating ducts in machine cores** *August 1960*

D. BROADBENT, B.SC., M.ENG.SC., PH.D., *and* K. N. STANTON, B.E. 395S, SEPTEMBER 1960 **An analytical review of power-system frequency, time and tie-line control** *September 1960*

T. H. O'DELL, B.SC. 396M, SEPTEMBER 1960 **The magnetic excitation inside a cylindrical thin-film ferromagnet** *September 1960*

Communicated discussion on **Flux distribution in a permeable sheet with a hole near an edge**

G. H. METSON, M.C., D.SC., PH.D., M.SC., B.SC.(ENG.), *and* M. F. HOLMES, B.SC. 397E, SEPTEMBER 1960 **The conductivity of oxide cathodes. Part 9—Thermoelectric power** *September 1960*

B. R. NAG, M.SC.(TECH.). 398E, SEPTEMBER 1960 **Forced oscillation in an oscillator with two degrees of freedom** *September 1960*

A. NATHAN, M.S., D.SC.(ENG.). 399E, SEPTEMBER 1960 **Matrix analysis of constrained networks** *September 1960*

R. A. WOODROW, B.SC. 400E, SEPTEMBER 1960 **Limitations on realizable response shapes for certain wide-band bandpass amplifier circuits** *September 1960*

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R. J. LOMAX, M.A., PH.D. 402E, OCTOBER 1960 **Unstable electron flow in a diode** *October 1960*

R. ONODERA. 403E, OCTOBER 1960 **A new approach to Kron's method of analysing large systems** *October 1960*

PROF. J. GREIG, M.SC.(ENG.), PH.D., *and* K. SATHIRAKUL, B.SC.(ENG.), PH.D. 404S, OCTOBER 1960 **Pole-face losses in alternators** *October 1960*

H. F. HARMUTH, DIPL.-ING., DR.TECH. 405E, OCTOBER 1960 **Audio communication with orthogonal time functions** *October 1960*

N. N. HANCOCK, B.SC.(ENG.), M.SC.TECH., *and* B. H. KARAKARADDI, B.SC., M.SC.TECH. 406U, OCTOBER 1960 **The physical realization of induction-motor equivalent circuits** *October 1960*

H. S. HEAPS, B.SC., M.A. 407E, OCTOBER 1960 **Optimum combination of pulse shape and filter to produce a signal peak upon a noise background** *October 1960*

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P. J. B. CLARRICOATS, B.SC.(ENG.), PH.D. 409E, OCTOBER 1960 **Propagation along unbounded and bounded dielectric rods. Part 1—Propagation along an unbounded dielectric rod** *October 1960*

P. J. B. CLARRICOATS, B.SC.(ENG.), PH.D. 410E, OCTOBER 1960 **Propagation along unbounded and bounded dielectric rods. Part 2—Propagation along a dielectric rod contained in a circular waveguide** *October 1960*

PROF. C. M. ANGULO *and* PROF. W. S. C. CHANG. 411E, OCTOBER 1960 **The launching of surface waves by a magnetic line source** *October 1960*

J. LAIT, M.A., *and* A. J. HYMANS, M.SC. 412E, OCTOBER 1960 **The output spectral density of a detector operating on a f.m. c.w. radar signal in the presence of band-limited white noise** *October 1960*

O. E. MAINER, M.SC.(TECH.). 413U, NOVEMBER 1960 **Quantitative treatment of 3-phase brush-shifting series commutator motor** *November 1960*

P. R. BRYANT, M.A., M.SC., PH.D. 414E, NOVEMBER 1960 **The algebra and topology of electrical networks** *November 1960*

R. DAVIS, M.SC., *and* R. W. E. COOK. 415S, NOVEMBER 1960 **The surge corona discharge** *November 1960*

B. J. PRIGMORE, M.A., M.SC.(ENG.). 416U, NOVEMBER 1960 **Temperature rises in electrical machines with sustained variations in load and speed** *November 1960*

R. MADDEN, B.S. 417E, NOVEMBER 1960 **The indeterminacies of measurements using pulses of coherent electromagnetic energy** *November 1960*

R. S. MAMAK, B.SC., *and* E. R. LAITHWAITE, M.SC., PH.D. 418U, NOVEMBER 1960 **Numerical evaluation of inductance and a.c. resistance** *November 1960*

PROF. J. C. WEST, PH.D., D.SC., J. L. DOUCE, PH.D., M.SC., *and* B. G. LEARY, B.E. 419M, NOVEMBER 1960 **Frequency spectrum distortion of random signals in non-linear feedback systems** *November 1960*

D. P. ATHERTON, B.ENG. 420M, DECEMBER 1960 **Stability of a feedback system containing a limited-field-of-view error detector** *December 1960*

A. WRIGHT, M.SC. 421S, DECEMBER 1960 **Limitations of distance-type protective equipment when applied to long extremely-high-voltage power lines** *December 1960*

OBITUARY

GEORGE WILLIAM OSBORN HOWE

George William Osborn Howe, D.SC., LL.D., Emeritus Professor of Electrical Engineering at Glasgow University, died on the 7th November 1960. He was born on the 4th December 1875 at Charlton, Kent. He was educated at Roan School, Greenwich, and apprenticed to Siemens Bros., Woolwich. During the seven years he remained with the firm, he distinguished himself at evening classes at Woolwich Polytechnic by obtaining a Whitworth Exhibition and a senior county scholarship. Following three years of study at Armstrong College, Newcastle upon Tyne, graduating with honours in 1900 and also becoming the senior Whitworth Scholar of that year, he received practical training for two years with Siemens and Halske, Berlin.

In 1903 he became lecturer in charge of the electrical engineering department at Hull Technical College, and proceeded in 1905 to a lectureship at the City and Guilds Engineering College, London. In 1909 he became assistant professor, a position he held until 1920 when he was appointed head of the department of electrical standards and measurements at the National Physical Laboratory. In 1921 he was appointed the first James Watt Professor of Electrical Engineering, University of Glasgow; he retired in 1946.

Although particularly interested in radiotelegraphy, his understanding of fundamental principles—in which he had no equal and which amounted to genius—and his early practical training enabled him to apply himself to all branches of electrical engineering. His lectures were models of lucidity; and, with a keen and wholesome sense of humour, he had the art of making difficult things seem simple. His unrivalled skill at the blackboard will also be remembered by all those who came under his influence.

He read papers to the Royal Society, the Physical Society and the British Association, as well as contributing to scientific periodicals. There is no doubt he enjoyed disturbing the complacency of those who felt that a modern outlook was infinitely superior to that of antiquity, particularly if that modern outlook violated some fundamental principle. His work on the propagation of electromagnetic waves, and the effects of the Earth and of the Heaviside layer on them, led to some of the first calculations of the power required for long-distance transmission.

A further aspect of his work was that in 1926 he became editor of the *Wireless Engineer* and continued in this position for 28 years.

He was held in affectionate regard by his staff, who found him always available and helpful. Those who trained under him will ever be indebted to him for the advice and encouragement which he so freely gave them. It is not only as a scientist that he remains in the memory of those who knew him, but as an engaging personality and a courteous English gentleman. He is survived by a daughter.

He joined The Institution as an Associate Member in 1905 and was elected a Member in 1910. He served as chairman of the Wireless Section from 1921 to 1923, and on the Scottish Centre Committee in 1925–26 and from 1929 to 1936, being chairman in 1931–32. He was the first Faraday Lecturer in 1924, presenting a paper entitled 'World-wide radiotelegraphy', which was published in the *Journal* in 1925. Other papers, for two of which he was awarded an extra premium in 1916 and a Wireless Premium in 1920, were published in the *Journal* in 1916, 1920, 1921, 1925 and 1950. He was made an honorary LL.D. of Glasgow University in 1947. In 1956 he was awarded the Faraday Medal, and was elected a Fellow of the American Institute of Radio Engineers for 'his pioneering work in radio and his outstanding contributions to engineering education'. A. J. S.

JOHN McDERMOTT

John McDermott who died on the 5th October 1960 was born on the 30th June 1875. He was educated at St. Columbus Day Schools, Glasgow, and was apprenticed to Clarkson and Beckitt, Glasgow, studying part-time at Napiershall Street School.

In 1896 he joined Babcock and Wilcox for six months and was then engaged in the electrical equipment of ships with Mavor and Coulson, Siemens Bros., Glasgow, and the Faraday Engineering Co., Govan. During this period he studied electrical engineering part-time at the Royal Technical College, Glasgow.

In 1897 he was engaged as foreman electrician with R. D. Cassells and R. D. Livingston, Glasgow. In 1913 he joined John Dickinson, Hemel Hempstead, as chief electrical and power-plant engineer and manager of the power-plant department. Part of his duties included making critical examinations and comparisons of plants and works at home and abroad, particularly in the United States. He retired in 1939.

He was greatly interested in foreign travel and, until the Second World War prevented it, spent all his holidays abroad. Immediately he returned from one holiday he would begin planning for the next one. He visited Russia, America, Spain and the Balkan States.

He is survived by his widow, three sons and two daughters.

He joined The Institution as an Associate Member in 1925 and was elected a Member in 1930. He served as Honorary Secretary of the New Zealand Oversea Committee from 1937 to 1939.

J. M. W.

HERBERT CHEETHAM SIDDELEY

Herbert Cheetham Siddeley who died in Buenos Aires on the 6th August 1960 was born on the 26th June 1871 at Bowdon, Cheshire, where his family had lived for generations. He was educated at Rose Hill School, Bowdon, and was apprenticed to C. L. Baker, Manchester, studying electrical engineering at Manchester Technical School.

On the completion of his training in 1893 he joined the electrical department of the London and North Western Railway, Stockport, as draughtsman and works manager. In 1902 he joined the Lancashire Dynamo and Motor Co., Manchester, and was for many years sales engineer and manager in London. During this time he was very active in the formation and development of the B.E.A.M.A. On leaving Lancashire Dynamo in 1916 he was for some years in business on his own account in London. In 1932 he was appointed B.E.A.M.A. representative in the Argentine. On the termination of this contract, he joined H. W. Roberts, Buenos Aires, and was in charge of the engineering section until he retired in 1952.

In his younger days he achieved many successes as a long-distance cyclist. He was also a keen golfer. He is survived by his widow and a daughter.

He joined The Institution as an Associate in 1904 and was elected a Member in 1929. He served as Chairman of the Argentine Branch in 1937–38 and 1945–46 and on the Branch Committee in 1938–39 and 1946–47. R. W.

OSCAR CANDISH WAYGOOD

Oscar Candish Waygood, O.B.E., who died on the 31st October 1960 was born in Devonshire on the 19th November 1887. He was educated at Plymouth High School, at a public school in Ireland and at a school in Manchester, followed by part-time study at Salford Technical College and at Manchester College of Technology while apprenticed to Mather and Platt for five years.

In 1909 he joined Sunderland Forge and Engineering Co. as a draughtsman, transferring to English Electric, Preston, in 1910. In 1911 he became assistant chief draughtsman with Metropolitan-Vickers Electrical Co., Manchester, where he remained until he was appointed lecturer in electrical engineering at Liverpool University in 1919. He held this position until 1931 when he became chief engineer with Lewis's Ltd. During the Second World War he was seconded to the Ministry of Food and from 1940 to 1946 acted as chief technical adviser to the wartime meals division. He retired from Lewis's in 1952 as chief engineer and was their consulting engineer until his death.

His hobbies were tennis and golf and he was very interested in the Presbyterian Church, of which he was an elder. He was of irreproachable and forceful character, although somewhat brusque at times. He is survived by his widow and a daughter, his only son having been killed flying with the Royal Naval Air Service.

He joined The Institution as an Associate in 1912 and was elected an Associate Member in 1918 and a Member in 1924. He was honorary secretary of the Liverpool Sub-Centre from 1919 to 1922 and of the Mersey and North Wales Centre from 1922 to 1934, served as vice-chairman and chairman of the Centre from 1933 to 1935 and in 1935–36 respectively, and served on the Installations Section Committee from 1941 to 1943. He was appointed an Officer of the Order of the British Empire in 1944.

JAMES WILLIAM JOHN TOWNLEY

James William John Townley, C.B.E., who died on the 29th November 1960 was a well known figure in the electricity supply industry. He was born on the 12th December 1885 and was educated in Glasgow and at Camphill School, Paisley. He received practical training with Young and Aish for two years and further experience with Paisley and Manchester Corporation Electricity Departments, studying part-time at Paisley Technical College and at Manchester School of Technology. He served in other municipal electricity supply undertakings, including Ashton under Lyne, Sunderland, Barnsley and Bradford.

In 1927 he became chief electrical engineer to the London County Council Tramways Department and in 1929 was appointed engineer and manager of the County Borough of West Ham Electricity Department. In the years up to the Second World War, West Ham developed rapidly, but the war brought an end to this development and posed new problems following the intensive bombing of the docks and East London. Throughout the war he remained in control and planned West Ham 'B', the new generating station, which was ultimately built on the existing site.

He was president of the Municipal Electrical Association in 1941–42; chairman of the Electricity Supply Joint Committee in 1944; a member of the Public Utilities Coal Committee formed in 1941 by the President of the Board of Trade; and was actively engaged in the work of the electricity supply industry's joint negotiating machinery from 1927. His sterling work for the industry was recognized in 1946 when he was appointed a Commander of the Order of the British Empire.

He occupied a prominent place among the borough electrical engineers and managers who, in the years up to the 1948 Electricity Act, did so much to build up the prestige of municipal electricity supply. His death will be mourned by his many friends in the industry.

He joined The Institution as an Associate Member in 1919 and was elected a Member in 1948. He served as vice-chairman of the North Midland Centre from 1925 to 1927 and as a member of Council from 1931 to 1934. A. E. M.

SOME RECENT BOOKS

THE RELAY PROTECTION OF HIGH VOLTAGE NETWORKS

G. I. ATABEKOV

PERGAMON PRESS. 1960. 564 PP. £4 4S.

THE author of this text, Prof. Atabekov, is an outstanding Soviet engineer who has devoted much of his time to the study of the relay protection of high-voltage networks.

The book gives a good idea of the state of the art of protection in the Soviet Union, which is of a very high standard, and provides the protective-gear specialist with a great deal of information on the results of investigation work on many important aspects, such as symmetrical-component filters and methods of calculating transient processes, about which there has been little publicity. The work is, however, too advanced for students seeking to gain a general knowledge of protective gear.

Important omissions are considerations of the questions of back-up protection and transformer and generation protection. The first few chapters are devoted to a study of unbalanced conditions in power systems, introducing symmetrical-component theory and the method of vector loci. A large section is devoted to distance protection and carrier protection, which are the principal types used in the power systems of the Soviet Union. There is a useful chapter on devices for the selection of the faulty phase in single-phase automatic-reclosure schemes.

In the first chapter, an analysis of the faults and failures in power systems is given, and it is interesting to note that 11·9% are due to the faulty action of relay protection and automatic devices while 15·2% are due to mistakes of personnel. Also, there are more faults in the electrical parts of generating stations and substations than on the overhead-line and cable networks. We are told in the introduction that Soviet relay-protection specialists will solve the problems confronting them with flying colours and ensure continuity of supply in the power systems.

Considering the high price of the volume, the printing is not all that could be desired. W. CASSON

DIGITAL COMPUTER FUNDAMENTALS

T. C. BARTEE

McGRAW-HILL. 1960. 342 PP. £2 10S. 6D.

THIS work is unusual in that it covers all the main aspects of electronic digital computers, their uses, programming, number systems, circuits, logical design, and peripheral equipment. The balance between these topics is well maintained, although there may be a slight preponderance towards logical design. It is therefore to be recommended to those entering this field of work and to those with a general interest in the subject.

British work and equipment are virtually ignored, and (perhaps because of this) inadequate treatment is given to the modification of addresses in instructions and to the interrelation of the stores in a computer—both of basic importance. H. McG. ROSS

EXPLORATION IN MANAGEMENT

W. BROWN

HEINEMANN. 1960. 326 PP. 30S.

THIS work, based on a study of management over many years, is written by the chairman of a large and successful company. It sets out in detail the policies and organizational ideas derived therefrom which have been in daily use in his firm for over five years. It also indicates quite clearly the fields in which further work remains to be done.

The author's work will be best understood, and probably most appreciated, by the practising manager of long experience who will compare it with his own experience, and will either confirm his own practice or be stimulated to further thought which might result in useful modifications.

This work is, to a degree, built around the personality of the author, and some managers will not agree with certain of his procedures, even after further studying their own operations as he suggests. This implies that the volume cannot be fully recommended as personal reading for senior students. It can, however, be studied with advantage as a

textbook under the tuition of one who understands the broad principles of management study. Many chapters can be assigned as straightforward reading, but others should be the subject of discussion under knowledgeable teaching staff.

The text could also be read with advantage by those studying the social aspects of modern management and by serious students on 'the other side', i.e. the representatives of staff and workpeople who have to put their constituents' views to management.

It is sometimes said that good managers are too busy managing to have time to write about it. It is gratifying that some good managers recognize a duty to their successors, as in this instance, and an excellent book has been written.

A. JACKSON

TRANSLATION FROM RUSSIAN FOR SCIENTISTS

C. R. BUXTON and H. S. JACKSON

BLACKIE. 1960. 299 PP. 30S.

THIS volume, according to the authors' preface, is designed to help scientists acquire a minimum knowledge of Russian necessary to read Russian publications.

Russian differs from western languages in many ways. Its alphabet is different, and the grammar, with its rules and exceptions, requires some study before the reading of Russian can be attempted.

In the first 90 pages, the authors deal with the alphabet and the peculiarities of the grammar. The exercises in the remaining pages consist of short excerpts from Russian scientific textbooks and periodicals, which offer a wide variety in the fields of physics, electronics, chemistry, mathematics, medicine, etc.

The many publications of Russian research and learning institutes are of great importance to all scientists working on the same, or similar, problems outside the Soviet Union.

The publication of this work will be welcomed by many interested in learning sufficient Russian to follow the progress of Russian research and science.

S. AISENSTEIN

ELECTRONIC CIRCUIT ANALYSIS. Vol. 1—PASSIVE NETWORKS

P. CUTLER

McGRAW-HILL. 1960. 454 PP. £3 2S.

ONE of the main difficulties encountered in the training of technicians is the limited mathematical knowledge of the student, and it is not easy to teach the analytic techniques appropriate to electronic circuits without the mathematical tools which are available to the university undergraduate. This book must therefore be welcomed as a serious and successful attempt to overcome this difficulty. It offers a complete treatment of electronic network analysis suitable for students taking H.N.C. and other technician's courses.

The volume has five chapters dealing, respectively, with network analysis and theorems, a.c. circuit analysis, transient analysis, transformers, and the graphical analysis of vacuum-tube circuits. Each section includes a large number of well chosen worked examples. The author's technique in avoiding the introduction of advanced mathematics is quite fascinating in places, particularly when dealing with transient analysis.

It is written in colloquial style and is very easy to read, although in some cases the terminology jars slightly; a new verb 'to thevenize' is used in many places.

It is a pity that the author has taken the direction of current flow as being that of electron flow. This is not the usual practice, and one cannot help feeling that this change can only cause confusion in the minds of students used to the normal convention. This is a point which must be very seriously considered before this work is recommended for adoption as a textbook.

Despite these and other minor points of criticism, such as the use of the word 'vector' when describing the impedance operator, the book is excellent, and teachers of this subject will find it an invaluable aid to their job.

F. C. WIDDIS

PRINCIPLES OF CONTROL SYSTEMS ENGINEERING

V. DEL TORO and S. R. PARKER

McGRAW-HILL. 1960. 686 PP. £5 12S. 6D.

THE rate at which books on automatic control are now appearing is so great that no reviewer can honestly pretend to compare the merits of one with another. This work aims at presenting a treatment of control systems, essentially from an electrical point of view, at American senior-graduate level. Its own level, however, is very uneven indeed, and while some chapters are lucid, others are not.

The first four parts pursue the theory of the subject in the historical order in which it developed, but manage to weight the scales heavily in favour of the root-locus approach by avoiding all mention of conformal plotting in connection with harmonic-response diagrams. The fifth section, on the use of analogue and digital computers in solving control problems, is good, but leaves the reader without any conception of the use of describing functions or other techniques which are available to those without computers who must nevertheless solve non-linear problems.

The last chapter is entitled 'Special topics', but in fact it deals with only one aspect of self-adaptive systems.

D. B. WELBOURN

FERNSEH-MESSTECHNIK

W. DILLENBURGER

BERLIN: FACHVERLAG SCHIELE UND SCHÖN GMBH. 1960. 373 PP. DM 45

THE whole range of voltage, current, impedance, temperature, and electrical and optical measurements specific to television are covered in an up-to-date qualitative treatment, with a large number of excellent diagrams and photographed oscillograms.

Of particular interest are the chapters dealing with specialized problems: gamma measurements on receiver- and camera-tubes and photocells (33 pages); modulation depth and resolution (18); spurious signals and interference (18); photosensitivity, storage, decay, focusing, secondary-emission

characteristics of electron-optical convertors (36); d.c. clamping and automatic gain control (28); carrier- and video-amplifiers (30); and phase- and group-delay measurements (22).

Specialized accounts also cover measurement of generator internal impedances, time-base performance, and mains supplies, and there are brief descriptions of modern electronic and optical test instruments and methods. For each of the 28 chapters a separate list of references is quoted, and a detailed index is provided. The text cannot avoid being somewhat brief and elementary, considering the enormous range covered; as a handbook of television test techniques, it is an excellent introduction to specialized and more thorough studies.

A. LANDMAN

SOLID STATE PHYSICS IN ELECTRONICS AND TELECOMMUNICATIONS

Vols. 1 and 2. SEMICONDUCTORS—Parts 1 and 2
Vols. 3 and 4. MAGNETIC AND OPTICAL PROPERTIES —Parts 1 and 2

M. DÉSIRANT and L. J. MICHIELS (*Editors*)

LONDON AND NEW YORK: ACADEMIC PRESS. 1960. Vol. 1, 638 pp. Vol. 2, 646 pp. Vol. 3, 557 pp. Vol. 4, 406 pp. Vols. 1–3, £6 8s. 6d. each. Vol. 4, £5 14s. 6d.

THESE four volumes, 2247 pages in all, contain reprints of some 250 papers which were presented at a conference sponsored by the International Union of Pure and Applied Physics and held in Brussels during June 1958.

Clearly, in the course of a brief review, any attempt to deal with individual papers is out of the question, and one can only say that the general standard appears to be well up to the level to be expected on such occasions, that the editors have done their work efficiently, and that the printing and binding of the books leave little to be desired. There is no record of any discussion to which the papers may have given rise.

One irritating omission is the failure to provide adequate indexes. In each volume there is an alphabetical list of authors (without corresponding page references) and a list of titles and authors, classified by subject and arranged in random order (with page references). Thus, even when one knows the title and the author(s), it is a tedious business to find the paper.

The first two volumes are concerned with semiconductors, and most aspects of the topic receive attention. Papers on group IV semiconductors occupy a good deal of space, and so do those on the preparation and properties of compound semiconductors. Various aspects of theory are considered, there are sections on devices and on applications, and there is an interesting group of papers on power rectifiers. Smaller sections are devoted to noise, surface phenomena and the effects of intense electric fields.

Vol. 3 is concerned with magnetic materials. The properties and applications of ferrites are well to the fore, but other magnetic materials are not neglected. There is a section on garnets and another on magnetic resonance.

The greater part of Vol. 4 is devoted to optical properties: to electroluminescence, applications of photosensitive materials, and the properties of phosphors. In this volume there are also sections on masers, radiation damage and miscellaneous problems.

With this wealth of good material it is perhaps ungracious to ask whether the four volumes should ever have been published, but the question is not without interest. Here we have 250 papers which, in other circumstances, would presumably have appeared in the usual periodicals—unless, in a few cases, referees had decreed otherwise.

It is unreasonable to suppose that all these papers came to fruition at exactly the same time: some must have been held up for the conference, while others might have been improved if a little more time had been available to the authors. In any case, the average delay between submission and publication has been nearly two years—a long time for a rapidly advancing subject.

These remarks are certainly not intended as a criticism of the editors or publishers, who deserve our thanks for having undertaken a task of considerable magnitude. May it not be, however, that there is something to be said for keeping conferences as informal as possible and leaving authors to publish through the usual channels? Papers would then get into print more speedily, would appear in appropriate journals and would be properly indexed for future reference.

C. W. OATLEY

THEORY OF A.C. CIRCUITS

S. FICH and J. L. POTTER

MACMILLAN. 1959. 453 pp. 35s.

THERE is a wider field here than the title might suggest. The authors have as their aim the establishment of a sound foundation for the study of modern network and communication theory on a fairly broad basis. The treatment is essentially mathematical, and much of the mathematics required for the understanding of the electrical theory is developed separately.

The first four sections are devoted respectively to basic energy relationships, complex algebra, series and parallel circuit combinations, and resonance phenomena. Network relationships are expressed in terms of straightforward differential equations, which are solved in the classical manner without resort to operational techniques.

Chapters 5 and 6 are concerned with network analysis. The subjects treated include the elements of network topology, the matrix solution of network equations, the T-π transformation, and the theorems of equivalence, superposition and reciprocity. Chapters 7 and 8 apply the techniques developed in previous sections to the analysis of inductively coupled circuits and polyphase circuits.

Chapter 9 is devoted to the Fourier analysis of both steady-state and transient waveforms, and concludes with a short but valuable section on the properties of the correlation function. In chapter 10 the Laplace transform is introduced and its relation to the Fourier transform is clearly set forth. Its application is illustrated by several worked examples. The final section provides a useful introduction to that almost inexhaustible topic, the synthesis of two-terminal reactive networks.

The volume is well illustrated, the topics are well chosen,

and the style is lucid. Moreover, its value to the student is enhanced by the provision of problems at the conclusion of each chapter. Books in this field are legion, of course, and the reviewer can, without difficulty, recall reviewing at least several which are only half as useful at perhaps twice the price.

J. M. C. DUKES

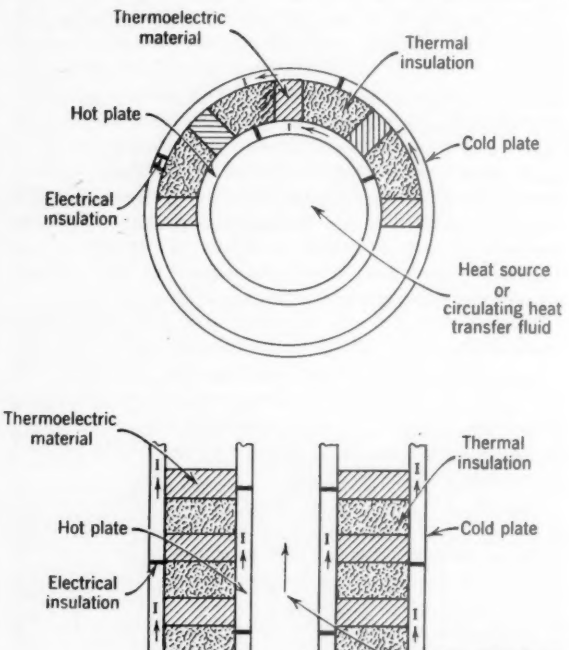
THERMOELECTRICITY

P. H. EGLI (*Editor*)

NEW YORK AND LONDON: JOHN WILEY. 1960. 407 PP. £4

THIS volume is based on the proceedings of a conference on thermoelectric energy conversion held in 1958 and sponsored by the United States Naval Research Laboratory. The papers presented at the conference have been supplemented by others in an attempt to give comprehensive coverage of the whole field.

The first of the four sections deals with the fundamental concepts of thermoelectricity. It provides an introduction and discusses the factors which enter into the design of thermoelectric devices. The second part surveys our present knowledge of the transport effects which control the efficiency of thermocouples. A number of chapters follow which discuss the properties of materials at high temperatures and show where research in this region can most usefully be carried out. The last section deals with experimental techniques for the determination both of the thermoelectric parameters and of other properties which would prove important in practical applications.



Typical thermoelectric-generator configurations

In a work of this kind it is inevitable that there should be some duplication, particularly of parts of the basic theory, but this may not be a bad thing since it enables each chapter to be understood independently. One may question the relevance of some of the work which has been included in several chapters, but there is no doubt that each contribution contains something of value to the reader. Quite clearly, Dr. Egli is to be congratulated on the way in which he has linked together the various topics; his summaries of the different sections and particularly his concluding chapter are admirable.

Much of what is contained in this book will become obsolete in the light of future developments. Nevertheless, it must remain for the time being a most useful addition to the literature on thermoelectricity, and it should be studied by all who are working in this field.

H. J. GOLDSMID

PROGRESS IN SEMICONDUCTORS—Vol. 5

A. F. GIBSON, F. A. KRÖGER and R. E. BURGESS (*Editors*)

LONDON: HEYWOOD. 1960. 316 PP. £3 3S.

TO say that this work maintains the standard of the previous four volumes in this series is in itself a sufficient recommendation. The editors have again persuaded acknowledged semiconductor experts to write exhaustive reviews of subjects in which they are interested. The reviews are therefore authoritative; they are also specialized and make few concessions to the reader not already familiar with the topics under discussion.

Although the authors have made personal contributions to the fields they discuss, they have managed, on the whole, to keep a detached view, as is testified by the appearance of nearly 100 references at the end of each article.

There is no particular relation between the articles, apart from their all being concerned with the properties and behaviour of semiconductors, but, as Dr. Gibson points out, there is some bias towards the optical properties of semiconductors.

The book is too advanced to recommend to anyone not already familiar with semiconductor research, but to the research worker surveying the frontiers of existing knowledge in order to find fruitful fields of work, this volume, like its predecessors, should be invaluable.

E. H. COOKE-YARBOROUGH

TECHNICAL COMMUNICATION

G. C. HARWELL

NEW YORK: MACMILLAN. 1960. 332 PP. 26S.

'WRITTEN and oral expression is an essential part of technical work.' So this book begins—and it continues with excellent guidance to the engineer on improving his command of expression. Not surprisingly it is American, for the growing need for better technical communication is grasped more among American than British engineers. Mr. Harwell (of Duke University) writes primarily for students, but few, very few, qualified engineers could not learn from him, although they might excuse themselves from trying his exercises in reporting on noise in the dormitories and other campus problems.

The technical compositions discussed are the business letter, the report and the article. Within its scope the book is admirable. Indeed it shines as a rare book on technical literature that lives up to its own tenets—and in writing about writing, example is better than precept; Mr. Harwell shows a nice sense of functional style, even if his short sentences lead sometimes to jerkiness.

Although inevitably some practical details are irrelevant to Britain, the advice on letters is sound, and those who habitually write from office or laboratory in the third person and passive voice will do well to mark it. In a full survey of report writing, Mr. Harwell becomes too elaborate: there are nine different types of report, with many variations in ending based on combinations of 'results', 'recommendations' and 'conclusions', and intricacies such as 'fifth-degree headings'. But although the trees have too many branches, the wood is well planted.

The discussion of articles ably brings out the different approaches required in writing an article and a report. The chapter on oral communication is apt and includes, apart from succinct advice on public speaking, some notes on visual aids, business conferences and interviews.

The author provides a reference section on grammar, punctuation, spelling, rhetoric and usage, which shows an unusual definiteness and clarity on controversial points. Only in minor ways does the guidance conflict with normal British practice.

An asset of the work is the many practical examples of letters, reports and articles. Notable omissions in the author's coverage are production processes, publication arrangements and the writing of books—the most effective medium for conveying durable information. But this last omission, by its sheer self-inconsistency, succeeds in emphasizing that 'Technical communication' is itself a fine exponent of its title.

C. T. RIVINGTON

THE ELECTRO-EROSION MACHINING OF METALS

A. L. LIVSHITS

BUTTERWORTHS. 1960. 115 PP. 30S.

THIS summarizes developments to date in the machining of metals by processes classified under the term 'electro-erosion', which covers both dimensional machining and the change of surface properties, e.g. surface hardening.

When the so-called spark-machining process was introduced some years ago, it attracted immediate interest, and the advances discussed in this book have since led to the increasing use of electro-erosion methods as a means of simplifying numerous production problems. The author gives detailed information on the fundamentals of all aspects of electro-erosion, compares the different methods of machining metals in these relatively new ways, and discusses the generation of the pulsating-current supplies required. Chapters are devoted to automatic control, to electrochemical characteristics, and to the machines actually used for carrying out the dimensional cutting of metals. The survey is comprehensive, and nothing of importance seems to have been omitted.

The text is clearly written and well illustrated, although the reproduction of some of the photographs could have been improved. All those seeking information on this specialized but important subject will find it useful.

J. W. CUTHBERTSON

THE UNIVERSE OF RELATIONSHIPS

J. H. REYNER

VINCENT STUART. 1960. 130 PP. 25S.

FEW members between the ages of 30 and 60 can be unfamiliar with the author's name. Many will know his sunny wisdom and kindly guidance at first hand, for he was for many years a frequent and welcome visitor to Graduate and Student Sections all over the country during his Editorship of the *Students' Quarterly Journal.*

The theme of this book is perhaps unexpected, but it will not surprise those who know its author. It is a seeking after another facet of man's life and its meaning. The universe we study is one of relationships. The world we know is only a small part of reality, set in a vastly greater *unmanifest* universe. Our own limitations prevent us from seeing; but not from feeling, for if we forsake an arrogant denial of a Higher Intelligence, we can form new concepts and glimpse a wider cosmos.

Mr. Reyner ranges through the realms of known science—chemistry, vibrations, atoms, electrons, nuclei, the living cell. He draws parallels between octave ranges in vibration, in size and in lifetime. The scientific part is well done, easy to read, and full of wonder. The conclusions are more difficult, less comprehensible. When words get their feet off the ground they become esoteric, and only with a wealth of illustration, analogy and (if you like) parable can some idea of their intended meaning be conveyed.

Mr. Reyner might consider, one day, a more developed philosophy and extend his final chapter far beyond its present limits. At least one reader is in sympathy with his aims, and needs more of his guidance.

M. G. SAY

ENGINEERING EDUCATION IN RUSSIA

S. P. TIMOSHENKO

McGRAW-HILL. 1959. 47 PP. 21S. 6D.

THIS is a valuable addition to the literature of Russian technological education. It opens with a historical review of the development of engineering education in Russia, for which alone the book would be worth reading. Some examples of Russian engineering curricula are given, but the author does not attempt the comprehensive survey and comparative analysis that have already been done in great detail by others.

Nevertheless, the account of the development of engineering courses during the last 40 years, and of the present system, makes a significant contribution to knowledge on this topic, for the author has first-hand information of conditions as a practising teacher in pre-revolutionary Russia. In this respect, the book supplements more detailed descriptions.

The thread of personal experience that runs through the volume gives it a human quality which, with its easy style, makes it a pleasantly readable document

The work is recommended.

H. E. DANCE

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

BOOKS

BARTENSTEIN, R., and LANGREHR, H. (*Editors*) 621.315.027.3

Die 400kV Forschungsanlage Rheinau. Teil 3—Störpegelmessung und Anderes (The 400kV experimental installation at Rheinau. Part 3—Noise level and other measurements)

Heidelberg: 400kVForschungsgemeinschaft e.V., 1960. pp. 97. 30 × 21cm. n.p.

Gives results of investigations of h.f. interference from high-voltage lines, measurement of corona losses, and measurement of mechanical characteristics of lines, such as sag and tension.

BELL, S. W., and MATLEY, H. 517

Mathematics for higher national certificate: a textbook for the use of first year (A1) students. **Vol. 1, 2nd edition**

Cambridge: University Press, 1959. pp. xii, 311. 22 × 14cm. 16s.

This is a textbook on calculus and is intended for engineering students. It contains many worked examples and exercises for the student to solve.

COLLIN, R. E. 621.392

Field theory of guided waves*

New York and London: McGraw-Hill, 1960. pp. xiii, 606. 23·5 × 15·5cm. £6 8s.

This comprehensive account of guided-wave theory gives the mathematical techniques and solutions of the more elaborate waveguide structures, waveguide discontinuities and coupling apertures. It will be reviewed in a future issue.

GLICKSTEIN, C. 534.321.9

Basic ultrasonics

New York: John Rider. London: Chapman and Hall, 1960. pp. 137. 24 × 16cm. 32s.

A very elementary description of the equipment used in applications of ultrasonics.

MASON, S. J., and ZIMMERMAN, H. J. 621.38

Electronic circuits, signals, and systems*

New York and London: John Wiley, 1960. pp. xviii, 616. 23·5 × 15cm. £5

Gives methods of analysing electronic circuits by using resistive models for diodes, triodes, pentodes and transistors. Graphical interpretations of signal operation are described. This book was reviewed in the September 1960 *Journal*, p. 553.

MENDELSSOHN, K. (*Editor*) 536.48

Progress in cryogenics.—Vol. 2

London: Heywood, 1960. pp. vii, 280. 25 × 15·5cm. £3 3s.

Another volume in a series containing summarizing papers on the production, maintenance and measurement of low temperature used not only for gas liquefaction but for developments in such fields as computers and microwave amplifiers. To be reviewed.

MOORE, R. K. 621.392

Traveling-wave engineering*

New York and London: McGraw-Hill, 1960. pp. xix, 360. 23·5 × 15·5cm. £4 5s. 6d.

A feature of this book is the development of analogies between different types of wave—electromagnetic, acoustic, waves in solids, etc. Steady-state a.c. and transient waves are discussed. There are chapters on plane-wave incidence reflection and spherical waves, lumped-parameter models and transmission problems involving telephone and power systems. This book was reviewed in the February 1961 *Journal*, p. 114.

ROBERTS, J. 621.318

High frequency applications of ferrites*

London: English Universities Press, 1960. pp. x, 166. 19 × 13cm. 16s.

For advanced students of electrical engineering and physics. It discusses the physical phenomena that are the basis of the properties of ferrites and the performance of systems having components incorporating ferrites at various frequencies including microwaves. It was reviewed in the February 1961 *Journal*, p. 115.

SCHURE, A. (*Editor*) 537

Magnetism and electromagnetism. Advanced magnetism and electromagnetism. 2 vols.

New York: John Rider. London: Chapman and Hall, 1959. Vol. 1, pp. vi, 71. Vol. 2, pp. vii, 96. 22 × 14cm. 37s. 6d. together

Two short introductory works. The second contains an interesting chapter on magnetism in technology and gives schematics to explain the cyclotron, betatron and mass spectrograph.

SHAW, W. F. B. (*Editor*) 697

Domestic heating: a guide to all forms of space heating and hot water supply systems for the home, using gas, oil, electricity, or solid fuels*

London: Temple Press, 1960. pp. x, 194. 23 × 14cm. 21s.

STEWART, J. L. 538.551

Fundamentals of signal theory*

New York and London: McGraw-Hill, 1960. pp. xiii, 346. 24 × 15·5cm. £3 10s.

This is on the mathematical techniques used for the study of linear and time-invariant systems. It will be reviewed in a future issue.

THALER, G. J., and BROWN, R. G. 621–52

Analysis and design of feedback control systems. 2nd edition*

New York and London: McGraw-Hill, 1960. pp. xiii, 648. 23·5 × 16cm. £5 12s. 6d.

Originally entitled 'Servomechanism analysis', this new edition discusses mathematical methods of transient analysis, polar and logarithmic frequency-response methods and root-locus methods. Physical explanations and worked examples are again included. It will be reviewed in a future issue.

THOUREL, L. 621.396.67

The antenna*

London: Chapman and Hall, 1960. pp. xii, 407. 24·5 × 15·5cm. £3 10s.

This is a comprehensive manual covering aerial systems of all types, especially those for v.h.f. and u.h.f. purposes. It includes practical formulae, and information useful to the designer.

ZEFFERT, H. 629.135

Principles and practice of aircraft electrical engineering*

London: George Newnes, 1960. pp. xv, 726. 22 × 14cm. £4 10s.

A detailed survey of the problems encountered from the design to the operational stage. It discusses the considerations dictated by climatic and environmental conditions, the different types of prime mover available, the choice of d.c. or a.c. power systems, batteries, distribution, and the various specialized arrangements and equipment for flight and communication requirements. It will be reviewed in a future issue.

THE INSTITUTION EXAMINATION

List of successful candidates

THE INSTITUTION EXAMINATION (PART I) OCTOBER 1960

BRITISH ISLES AND OVERSEA

The following have satisfied the examiners in the compulsory subjects of Part I (mathematics; applied mechanics; heat, light and sound; principles of electricity; and engineering drawing):

BARR, Arthur David
CHARLTON, Thomas Joseph
VERMEULEN, Adrian Isaac

The following candidates have satisfied the examiners in the subject of English:

BASS, Derek Malcolm
DEBBAS, Robert
GEORGE, Francisco Elkernal
GIBSON, Leonard
GULATI, Sat Pal
KARPATI, Kalman
LOCK, Roger David
ROGERS, Alexander Arthur Pearce Neville
SIMONSEN, Brian
TEICHNER, Thomas
TIDEY, Laurence Charles
TOMBS, Albert Henry
TREUREN, Gustaaf Hendrik George

The following candidates have been permitted to enter the Examination under special conditions and have satisfied the examiners in heat, light and sound:

ASPIN, Norman
AYRES, James Albert
RICHARDSON, John Robert
TAYLOR, Raymond Jack

THE INSTITUTION EXAMINATION (PART II) OCTOBER 1960

BRITISH ISLES

BAILEY, Gordon[2]
BARTLETT, Bryn Bayton[4]
BARTON, James Douglas[2]
BHATIA, Mansuralli Gulamhusein
BUTTERWORTH, Derek James[4]
CHAKRAVORTI, Ashit Chandra
DE, Bimal Bikash
EWENS, Stuart Christopher[1]
HARRISON, Paul Depledge
HARRISON, Ronald[2]
JONES, Ifan Bleddyn Lloyd[1]
KENNARD, David Edward
KING, Ernest[2]
KRISHNASAMY, Kanapathipillai[1 4]
LEWIS, Thomas Martyn Anthony[1]
MASKELL, Clifford William Alfred[2]
MEIR, Peter Frederick[2]
OWEN, David[2]
POOLEY, John Charles[1]
PRICE, Walter James[2]
RODRIGUEZ, Norman William[3]
SEN GUPTA, Rabindra Nath
SKELTON John[1]
THARMALINGAM, Sinnappu
TRAYNER, James Peter[4]
WEAVER, Leonard John
WHITBOURN, Edward Albert[4]
WILLIAMS, Brian George[2]

OVERSEA

BEAN, John[1 3]
ELLERY, Robin William
FLEMING, William George
HAZLEWOOD, Frank
RICHARDS, David John
SORRELL, Leonard Frederick

[1] *Electrical engineering I and II* [2] *Engineering physics* [3] *Thermodynamics* [4] *Mathematics*

THE INSTITUTION EXAMINATION (PART III) DECEMBER 1960

BRITISH ISLES

ABROOK, George Edward[7]
ALEXANDER, Robert John
ALLAN, Anthony Gavin[1]
ALLEN, Kenneth Royston[4 6]
ALLMARK, Alan[1]
ANDERSON, Albert Frederick William[1]
BAIRSTOW, Roy[1]
BALDWIN, David Arthur[5 7]
BARNES, David William[1]
BASS, Ronald Paton[1]
BATTEN, John Anthony[5]
BEANEY, Michael Edward[5 7]
BECKINGHAM, Brian Francis[1]
BEDSON, Leslie Stuart[6]
BIRKIN, Michael Sambrook[3 5]
BOHANNAN, Tony Donald[1]
BULL, Donald Malcolm[5 7]
BURDETT, Donald[1]
BURTON, Henry[6]
BYRON, John Raymond[1]
CARELESS, John Walter[1]
CASEY, Frank[2 6]
CASTLE, Anthony George[1 3]
CHANDLER, Kenneth[5]
CHARLTON, Ian John Austin[3 5]
CHEETHAM, Philip Gordon[5]
CHEFNEUX, Eric William[4]
CHRISTMAS, Colin[1]
CLARKE, Peter Terence[4]
CLYDE, Ronald Buchanan[1]
COOPER, Alan Cadmore[1 6]
COWLEY, Alan[7]
CRANSHAW, Arthur James[3]
CUSCHIERI, Albert Edgar[5]
DALE, Anthony Peter[5 7]
DAVIS, Brian William[1]
DAWSON, Michael John Groombridge[3 4]
DOWN, Bryan[1]
DUDLEY, Leonard William[5 7]
DUNNE, Thomas Francis[3 5]
ECONOMIDES, Dionysios Gregoriou[6]
FARQUHAR, Denis[1]
FISHER, Forest Francis Rutley[1]
FORSTER, John[6]
FOY, Kenneth Frank
GABRIELS, Kenneth[1 6]
GARDNER, John Leslie[1]
GEORGE, Emyr[7]
GILLANDERS, Robert[2]
GLEESON, Peter Thomas[3]
GOLDMAN, Arnold[1 4]
GOTH, Diana Raby[2]
GRANT, John Victor[1]
GREENWOOD, David[7]
GREENWOOD, David[1]
GREW, Richard John McIlroy[5 7]
GRICE, Peter Anderson[1]
GROVES, Lyndon Rees[5]
HALL, John
HAMILL, Bernard[1]
HANDFORD, Michael Phillip[7]
HARDING-JONES, Peter[1]
HARRISON, Ronald[1]
HASLAM, Harry Myles[1]
HINDLEY, Peter John[1]
HOCKING, John Marshall
HOLT, Ian Roscoe[3]
HOMBURGER, Ernst Raphael[3 8]
HOOD, Ronald John
HUGHES, Samuel Wesley[1]
HUNTINGTON, Alan[1]
INNES, Alexander Esson[2]
JACKMAN, David Radclyffe[5]
JACKSON, Brian[6]
JEBSON, Derek
JEFFERSON, Frank Jerome[1]
JOHNSON, Colin Peter[3]
JONES, Gareth Edward[6]
JONES, Trevor Vaughan[4]
JONES, Wyndham[6]
KILMINSTER, Robin Franklin[7]
KIRK, David William[4]
KNOTEK, Stenek[1 3]
LACEY, Edward Ernest[4 6]
LAWS, Alfred[1]
LEWIS, David Morgan[4 6]
LINES, David
LOFT, Graham Arthur[5]
MACKERTICH, Paul John[1 4]
McRAE, Ian Nelson
MAHENDRAN, Paramoo[2]
MAJUMDAR, Dipak
MANDERS, Gerald[1]
MANN, Ernest George[4]
MEIMERY, Seif Salim Seif[2 4]
METCALF, John Hugh[1]
METTANANDA, Asoka
MICHAEL, Ethelbert Victor[5 7]
MOBBS, John Charles William[1]
MOONEY, Roy Marshall[1]
MOORE, Bryan[5]
MORGAN, Thomas Geoffrey[4 6]
MORLEY, Alec Glynn[6]
MORRIS, John Henry[7]
MORRIS, Selwyn James[1 6]
NEAL, John Edward[1]
NORRIS, Bryan Leslie[5 7]
NORTH, Thomas William Tertius[1]
ORPEN, Vernon Ivan Norman Colin[1]
OULTON, Timothy Norman[6]
OWENS, Thomas Victor[3 5]
PALMER, Brian William[4]
PARAMESWARAN, Thamotharampillai Vaithilingam[1 4]
PEABODY, Christopher John[3]
PEDERSEN, Aage
PENDLEBURY, Joseph[6]
PICKERING, John Adrian[2 6]
PIGOTT, Peter Malcolm[3]
PILKINGTON, Donald James[5 7]
POTTER, Eric Frederick
POWLEY, John Robert[3]
PRICE, Nicholas Nadine Aitken[3]
PRINGLE, Anthony Edward[4]
PROBERT, Peter Ernest[3]
PULANTHIRAN, Eliathamby[3]
QUINN, Anthony
RAJANAYAGAM, Ilanganayagam[4 8]
REED, Donald Brian[1]
REED, Rodney Charles Ernest[5]
REID, Bernard Edsell[6]
RICHARDSON, Kenneth Charles Smart[1]
ROBINSON, Peter Beresford[3]
ROLFE, Derek Sidney[4 6]
SAMARAKKODY, Upali[2]
SAUNDERS, Trevor James[3 4]
SAVILLE, Brian[5 7]
SCRUTTON, William Henry Charles[3]
SHAW, James[5 8]
SHROPSHALL, Peter Edward[4]
SIDERAS, Christakis Stavros[1]
SIMMANS, Albert Frederick George[8]
SIMMONS, Derek Brian[1]
SINDEN, Edgar William[1]
SMITH, Lawrence[1]
SPARKS, Gordon Leslie[2]
SQUIBB, Christopher Maurice[1]
STAFFORD, Michael Robert[3]
STARKE, John Eric[1 5]
TAMBIPILLAI, Samuel George Kuneratnam[1 3]
TEN KLEY, Willem Berend[5]
TESSON Adrian Richard[6]
THAYANANDARAJAH, Somasundram[2 4]
THOMAS, Stuart[5]
THOMPSON, Brian Henry[6]
TIBBENHAM, William Percy[5]
TOKELL, Daniel Anthony[1]
VANDERSTEEN, Anthony David[1]
WARNE, Anthony John[1]
WELLBELOVED, Robert[1]
WHITE, Eric Simpson[1]
WHITE, Raymond Anthony[1]
WHITFIELD, Neville Stuart[1]
WOOD, Ivor Thomas[5 7]
WOOLLEY, Peter Maxwell[6]
WORTH, Alan[1]
WRAY, Jack[1 4]
WRIGLEY, David
YATES, Albert[7]
YOUNG, Arthur[4]
ZAINUDDIN, Mohammad Jalaluddin[4]

The Institution Examination: List of successful candidates (continued)

OVERSEA

ASHBY, Gerald Terence
BAILLIE, Theodore Henry[4]
BRASSINGTON, William John
CAMPBELL, Kenneth Scott
CARDNO, Ian Murray[1]
DE SOUSA, Armando Mariano Joseph
GOVENLOCK, Terence Edmund[1]
GRANGER, Murray James[4]
GRICE, Geoffrey George[1]
HANLON, Brian Leslie
JAMES, Roy Arthur[5]
KELMAN, Keith Douglas Edward[6]
LANG, Harvey Graham
LEAMAN, William Mark[1]
LEYLAND, Bryan William
McINTOSH, Ranald[5]

[1] *Advanced electrical engineering* [2] *Electrical machines* [3] *Electrical measurements* [4] *Electricity supply* [5] *Electronic engineering* [6] *Utilization of electrical plant* [7] *Radiocommunication* [8] *Line communication*

Elections and transfers

The following elections and transfers approved by the Council of The Institution are effective from the 1st February 1961

ELECTIONS

Associate Members

CARR, Cmdr. John Reginald, O.B.E., R.N.
CLEGG, Robert James, M.SC.
COLLIS, Alec Peter Orme, B.A.
COOPER, Donald Gordon Haig
DARE, Maj. Sydney Charles Bernard, B.SC.(ENG.), R.SIGNALS
DAVENPORT, John Layton, M.SC.TECH.
ELLIS, David Geoffrey, B.E.
HAINES, Gordon Edward, B.SC.
HALL, Maurice North, B.SC.(ENG.)
LAING, Robert Miller
LEARY, Brian Gilbert, B.E.
LONSDALE, Keith, B.SC.TECH.
LOWRIE, William Alexander, B.E.
PATTENDEN, Douglas Robert
SHIH, Samuel-Lung, M.S.
STAPLETON, Colin Arthur, B.SC., B.E.
STEVENSON, John Russell
TURNER, Harvey
WHITTAKER, Frank
WILLIAMS, Norman Lionel Gerald
WOODHEAD, Harry Stanley

Associates

FORD, Allan Ivor
HOCKIN, Thomas Luscombe
HUFF, Ronald Henry
JONES, Edward William
MACPHAIL, James Shaw

TRANSFERS

Associate Member to Member

BARRATT, Stanley
BENT, Ronald Albert
BEN URI, Joseph, DIPL.-ING., DR.-ING.
BISHOP, Thomas Richard John, M.B.E.
BOAG, David James Wilson, B.SC.
BOYD, Robert Lewis Fullarton, B.SC.(ENG.), PH.D.
CHRISTIANSEN, Prof. Wilbur Norman, D.SC.
COWELL, Antony Russell, B.A.
FORD, Lewis Hamilton, M.SC.(ENG.)
GENT, Robert James
GERRY, Cyril Harry
GWYN, David Glanville, B.SC.
McGLASHEN, Ronald, M.B.E.
MAKOWER, Abram, ING.DIPL.
STEPHENS, Cedric John, B.SC.(ENG.)
SYKES, Brig. Arthur Clifton, C.B.E., D.S.O.
TAYLOR, Reginald
THOMPSON, John Crighton, C.B.E., B.SC.
TOZER, Jack
WIDGER, Leslie
WILLEY, John Matthew

Graduate to Member

ADAMS, John Bertram, DR. ès SC.

Associate to Associate Member

BOURNE, William George

Graduate to Associate Member

ALBOROUGH, Maj. Albert John, R.E.M.E.
ALEXANDER, Charles Ernest
ALEXANDER, Ian Baxter
ANGUS, Donald Avery
BAILEY, Eric
BANTON, Colin William
BEEDHAM, Edgar
BELFORD, Timothy Morton
BENNETT, Philip
BERRY, Frank Roland
BOWERS, Stanley Howard, B.SC.
BRINSLEY, Clive, B.E.
BROWN, Maj. Dennis Alan, R.E.M.E.
BULL, Francis Keith
BYROM, Edward Paul
CEARNS, Clarence Malcolm Douglas, B.E.
CLAUSEN, Charles Henry
COLTMAN, Martyn
DATTA, Sankaracharyya, B.SC., B.E.E.
DAVIDSON, Geoffrey George
DAVIES, Edward John
DUCKWORTH, Herbert
EADES, Colin George
ELMS, Sydney, B.SC.
EVANS, Maj. Raymond Vincent, B.SC., R.E.M.E.
FEILCHENFELD, Michal Marceli, DIPL.-ING.
FLINT, Reginald Arthur
FOUNTAIN, Leslie John
FREDERICKS, Frank Roy, B.SC.(ENG.)
GALPIN, Geoffrey Stanley
GATENBY, Donald, B.SC.(ENG.)
GLICK, David
GREENHALGH, David Constantine, B.SC.TECH.
GRIFFITHS, Leslie William

Graduate to Associate Member (continued)

HALL, Edwin Joseph
HARDY, Jacques Philippe Roland, B.SC.(ENG.)
HATLEY, Ronald Gordon
HESLING-GIBSON, Edward
HIGGIN, Robert Michael, M.SC.
HILDRETH, George Henry
HOLLAND, Robert John
HUMPHERY, Douglas
HYDE, Norman Douglas, B.SC.
JACKSON, Michael Oldfield
JONES, John Graham, B.SC.(ENG.)
JONES, Leslie Edwards, B.SC.
KEAN, George Cruickshank, B.SC.
KING, Desmond
KODZ, Witold Tadeusz, DIPL.-ING.
LAWRIE, Frank
LEVY, Julius Frederick, B.SC.(ENG.)
LEWIS, Colin Arthur
LITTLE, John
LYON, Derek Charles, B.SC.
MACCORMACK, John, B.SC.
McILWRAITH, John Wallace Breckenridge
McKENNA, Peter
MADDAMS, Hugh Keith, B.SC.
MALCOLMSON, John Wardell, B.E.
MARTIN, Christopher John Blandy, B.SC.
MARTIN, Noel Stewart, B.SC.
MARTINEZ-PEREZ, Pedro
MATTHEWS, Peter Ash, PH.D., B.SC.(ENG.)
MAUND, Geoffrey Basil, B.SC.(ENG.)
MUKERJI, Prof. Mohi Mohon, M.SC.
MURRAY, James Hogg
NORMAN, Kenneth William
OWEN, Victor Thomas
PAGE, Peter John Abbott, B.E.
PAMMENT, Philip Stanley
PARKER, Frederick Walter
PARKER, Stephen James
PARKINSON, Charles Alfred
PATTERSON, George William Rowland, B.SC.
PERERA, Cottekankanange Neil Deepal
PURSE, Reginald George
QUIRK, William James
RAMSDALE, William
REEVES, Douglas Edward Allen, B.E.
ROSS, Samuel White
SAYWELL, Arthur
SIMPSON, Herbert
SKURR, John Alfred, M.SC.
SMITH, Albert Howard, B.SC.
SMITH, Norman Crawford, B.SC.(ENG.)
SOUTAR, Douglas
STEVENS, Keith Leslie
STUTCHBURY, Geoffrey James, B.E.
TILLEY, James Thomas
TURNER, Peter Alan
VERNON, Hubert Sidney
WARBURTON, Raymond Ivor
WATSON, Herbert Joseph, B.SC.(ENG.)
WATTON, Ernest Charles
WHITEHOUSE, Sidney James
WILLIAMS, George Edward
WILLSON, Stanley Russell, B.SC.(ENG.)
WOOD, Peter Graeme
WRIGHT, Colin Leonard

Student to Associate Member

COLE, James Edward, B.SC.
HANNA, John, B.E.

The following elections and transfers approved by the Council of The Institution are effective from the 2nd February 1961

ELECTIONS: 1st LIST

Graduates

BYLANSKI, Piotr Wladyslaw Jozef, B.SC.(ENG.)
CLOHESSY, Lewis Patrick Eugenio, B.E.
DUMOLO, Peter, B.SC.
FORSTER, John Allen, B.SC.
GEORGE, Francisco Elkernel
GOSWAMI, Bedabrata, B.SC., M.SC.TECH.
HEBBARD, John Ellesworth, B.SC.(ENG.)
HINCHLIFFE, Tom Alan, B.SC.TECH.
HOLDEN, William Newell, B.SC.(ENG.)
HYDE, Vernon Rowley
KRISHNA, Kocherlakota Venkata Gopala, D.SC., PH.D.
LONG, Albert Alfred
MACNAB, David Keith, B.E.
MASLONA, Jan
MELLOR, Malcolm Stuart, B.SC.
PALMER, Neil Frank, B.A.
PARRY, Ian Stuart, B.SC.(ENG.)
RICHARDSON, John Robert
RILEY, Peter Charles, B.SC.
SCRIVENER, Kenneth Ernest
SHADEKO, Herbert Iyitola, D.F.H.
STANLEY, Henry Yuan, B.E.
STEER, Nevil James, B.A.
UDDIN, Mohammad Imtiaz, B.SC.
VOSPER, John Vanstone, B.SC.(ENG.)
WARD, Alan William, B.SC.
WILLIAMS, Alan

Students

AHMED, Md. Alauddin, B.SC.(ENG.)
BIRCH, Nigel
BOLTON, Hugh Robert
BOTCHERBY, Alan White
BRIGGINSHAW, Bryan Alva
BURFORD, Lt. Dennis, B.A., B.A.I., R.N.
BUTLER, Leslie
CARTWRIGHT, Michael Richard Fox
CHAPMAN, Oliver Edmund
CHITNIS, Avinash Madhusudan
COMPSON, Brian
COOPER, David Thomas
DHARWAR, Hormaz Tehmurasp
DIXON, Richard Alan
ETHERTON, Anthony Cyril
EVANS, Hugh Norman
FERNANDO, Mudanagodage Sterling Coulton

Students (continued)

FRANSEN, Philip
GALLAGHER, John Joseph
GIBSON, Brian
GOADBY, Christopher Michael
HAMPTON-CHUBB, Myles Anthony
HEATH, David Henry
HERNIMAN, Keith
HICKMAN, Robert George Edward
HILLIER, David Reginald John
HOARE, Edward Ronald
HOCKEY, Stanley Newton
HOLLINGWORTH, Roger Gregson
HOOPER, Gerald Francis
IRVINE, Alan George
JAMES, Peter
KENCH, Ernest John
KITCHING, David Malcolm
LAKHANI, Azizuddin Hashim Ismail
LEE, Robert James
LITTLER, David John Phythian
LLOYD, Peter
McCARTHY, Alan James
McLEAN, John Bryan
MACNAB, Robert Beattie
MAHADEVAN, Sankarappillai
MAHANTI, Shailendra
MAYER, Philip Forster
MOHAMED, Zainoon Mohamed Alias Zainal
MORSE, John Newall
NEWBOLD, Philip Michael
NORTH, Robert Arthur
OSMOND, John Brian
OWUSU, Emmanuel
PHILLIPS, Roy Barry
PIKE, Ivor Brinley
POWELL, Graham Arthur John
PRENTICE, Herbert Donald
RAMSDEN, Peter Warren
RAWLINSON, Keith
ROBERTS, Eric
ROY, Prosanta Kumar
SHAW, Timothy Olaf Richard
SHOTTER, Geoffrey James
SMITH, David Graham
SMITH, George Michael
SODZI, Nathaniel Dotse
SPYRIDAKIS, Spyridon Origenous
SRIDHAR, Tiriuchendurai Viswanathan, B.E.
STACEY, Alfred, B.SC.
STANIER, David
STEELE, Colin
STEWART, Peter Alexander Mitchell
STRICKLAND, Lt. Peter Ivan, R.N.Z.E.M.E.
STRINATI, Angelo Giovanni Antonio Blaise
STURTIVANT, Peter John
SWALWELL, David Neville
SUTHERLAND, William Ian
TANNER, Anthony Frank
TAYLOR, Stuart Ross
THOMAS, James Michael
VIVIAN, David Anthony
WALKER, Charles Richard Eric
WALKER, Ian Fraser McKenzie
WALLIS, Christopher Norman
WALLIS, Terence Edward
WARING, Brian
WATTISON, Stuart David
WEATHERALL, Philip Miles
WEST, Keith Eric
WESTMORE, Roger
WILSON, Roger Anthony Perry
WISE, Malcolm Edward
WISSON, Peter Edmund
WRIXON, Gerard Thomas

TRANSFERS: 1st LIST

Student to Graduate

ALLARDYCE, Ian Robert, A.H.-W.C.
AYRES, James Albert
BAKER, John David, B.A.
BANERJEA, Kalyan Kumar, B.SC.(ENG.)
BLAYDES, Barry Paul, B.SC.
BRANDON, Martin, B.SC.(ENG.)
CHATFIELD, David John
CLARKE, Roy Thomas, B.SC.(ENG.)
DANIELS, David John, B.SC.TECH.
DEAKIN, Peter, B.SC.(ENG.)
DUTT, Ratan Bikash, B.SC.
FINLAYSON, John McLean, B.SC.
GEDGE, John Lewis, B.SC.
GIBBON, Robert Roger, B.SC.
GRAY, Albert, B.SC.(ENG.)
GREEN, Colin
HARRIS, John Godfrey, B.SC.(ENG.)
HARRISON, William Derek, B.SC.
HILLING, Anthony Edward, B.SC.(ENG.)
HOLDEN, Thomas Leonard, B.SC.
HUGGETT, Dudley John, B.SC.(ENG.)
HUGHES, John Barry, B.SC.
IBALL, Eric Kingsley, B.SC.(ENG.)
JONES, David John Robert
MEAD, John Frank, B.SC.TECH.
MILNE, Ian, B.SC.
MORGAN, John Adam, B.SC.
MURRAY, Hugh, B.A.
PALMER, David Stuart
PAMPLIN, Hugh Dean
PENERY, Michael Thomas, B.SC.
RALEY, Geoffrey Arthur, DIP.TECH.(ENG.)
REID, Robert
ROBINSON, Edward Henry, B.ENG.
ROSTRON, Alan
SCOTT, Robert Doyle, B.SC.
SHERWOOD, Stuart, B.SC.(ENG.)
SIMPSON, Anthony, B.SC.
SINGH, Satish Chandra, B.SC.
SKILTON, Roger Henry, B.SC.(ENG.)
SPEARS, Colin Crawford
VAUGHAN, Peter
WHALLEY, Anthony, B.SC.
WOODHEAD, Robert Barton

ELECTIONS: 2nd LIST

Graduates

ARORA, Santrain Singh, B.SC.
ASHWORTH, James Clive, B.A.
BERRY, Michael Arthur
BLACK, Christopher Thurson, B.SC.
CAVES, Alan James, B.SC.
CLARE, Gerald
DAVIS, Graham William, B.SC.
FARRINGTON, John Edward
FAULKNER, Francis, B.SC.
FIELD-RICHARDS, Nigel John
FORDHAM, Patrick James Samuel, B.A.
HALL, Alan Alfred
HARRIS, David John Edward
JOBSON, Peter Meredith, B.SC.
LUDBROOK, Roger James, B.SC.(ENG.)
McHENRY, Cormac Patrick, B.E.
MASON, John Bradford, DIP.TECH.(ENG.)
MORRIS, Robert William, B.SC.(ENG.)
MOTKIN, David Louis, B.SC.
MURDOCH, Henry James Paschal, B.E.
PURKIS, Barrington Granville, B.SC.
RAGHAVACHARI, Srinivasa, M.A., M.SC.
RANA, Pervez Edulji, B.SC., B.SC.(ENG.)
SKIPWORTH, Richard Teft
SUMMERS, Donald
TAYLOR, David Leslie, B.A.
VIRMANI, Ashok, B.SC., B.A.
WHITING, Kenneth Brian, B.SC.
WIDDOWS, Ernest, B.SC.(ENG.)

Students

ANDERSON, William
BAITS, John Charles
BAINBRIDGE, Derek Charles
BHOBE, Jagdish Vinayak
BURNELL, Charles John
BUSH, Douglas Alan

Students (continued)

BUTTON, Harold Fred, B.E.E.
CHAN, Min Hon
CHAN, Ming Kit
CHANG, Yue Chun
COATES, Barrie
CULLEN, Richard Nils
DAS, Swaraj Kumar, B.E.
DAVIES, Colin Godfrey
DAVIS, Edward John, B.SC.
FRANKLIN, Peter
GANDER, Robert Edward
GARDINER, Maurice John
GOLDSPINK, George Frederick
GRAHAM, John Francis
HAKEMAN, Noel Arthur
HARAM, Ronald Murrell
HARRAP, Keith
HINDE, Tom Faithwaite
HO, Ling-Hoi
HOCKHAM, George Alfred
HORDON, Austin
HOWLAND, John Edwin
JONES, Michael Spencer
KAUSHAL, Jagdish Chandra
LAM, Kin
LAM, Paul Kon Kwan
LEUNG, Ying Kit
LIGHT, Brian Rowland
LITTLEWOOD, Richard John
MATTA, Chandar Prakash
MITRA, Rupendra Lal, B.E.E.
MONRO, Ian Duke, B.A.
MORGAN, Elwyn George
MULLIGAN, Thomas
O'SULLIVAN, Stephen Gerard
PALSULEDESAI, Manohar Bhagwant
PATEL, Mahendra Rambhai
PEARSON, Nicholas David
POON, Ching Bor
RICHARDSON, John David
ROBINSON, Kenneth Leslie
ROLLNICK, Maurice
RUSSELL, Lawrence Victor
SEWELL, David John
SHERIDAN, Gerard Anthony
SMITH, Richard Bartlett
TAYLOR, Christopher James
TRICKETT, Keith Geoffrey
TURNBULL, Terence
VALLANCE, Roy Philip
VOWLES, Kenneth Leslie
WAI, Chun Wah
WALKER, Keith Noel
WHYTE, Michael Charles
WIGHTMAN, Eric
WINSOR, Eric
WONG, Sun Fat
YEUNG, Ching On
YOUNG, Terence Cullum
YUEN, Pui Sum

TRANSFERS: 2nd LIST

Student to Graduate

AKRAN, Claudius Dehumo Degra, DIP.TECH.(ENG.)
APPLE, Dennis, B.SC.
AXE, Roger Austin Charles, B.SC.TECH.
BENNETT, James Parkinson, M.SC.
COPE, Hugh Sinclair
DENNE, Phillip Raymond Michael, B.SC.
DENYER, Stuart
DREW, Ralph Francis, DIP.TECH.(ENG.)
ELKINS, Michael John, B.SC.(ENG.)
FARMER, Bryan Bigsby, DIP.TECH.(ENG.)
FROST, Peter Frank, DIP.TECH.(ENG.)
GIAM, Choo Huat, B.E.
GIBLIN, Roger Arthur, B.SC.(ENG.)
GLEESON, Peter Thomas, B.SC.
HOOD, Iain Gibson, B.SC.
HOSKIN, Brian John, B.SC.(ENG.)
LEWIS, Robert Tony, B.SC.
PASHLEY, Jack Christopher, B.SC.
PITCAIRN, John, B.SC.
RICKMAN, James, B.SC.
ROBINSON, Albert Edward, DIP.TECH.(ENG.)
ROGERS, Terry Gordon, B.SC.
SIMPSON, Howard, B.SC.(ENG.)
SMITH, George Brian, B.SC.
TURNBULL, Thomas James
WALKER, Derek Llewellyn, B.SC.TECH.

British Nuclear Energy Conference

DETAILS of three forthcoming meetings of the British Nuclear Energy Conference are given below. Papers and discussions on the applications of nuclear energy and ancillary subjects are published in the quarterly *Journal of the British Nuclear Energy Conference*. The annual subscription payable by members of The Institution who wish to receive the quarterly regularly is 30s. post-free. Single copies are available at 7s. 6d. each

1961

MARCH 21 *Tuesday* (2.30 p.m.)

Sponsoring society: Institute of Metals
Place of meeting: Church House, Westminster, London S.W.1

Discussion on COMPATIBILITY PROBLEMS IN GAS-COOLED REACTORS

APRIL 17–18 *Monday–Tuesday*

Sponsoring society: The Institute of Physics and The Physical Society
Place of meeting: University of Birmingham

Conference on NUCLEAR ENERGY. Information on contributions and arrangements may be obtained from Dr. G. D. Burkhardt and Dr. P. M. Rolph at the Department of Physics, Birmingham University

APRIL 24 *Monday* (5.30 p.m.)

Sponsoring society: Institution of Chemical Engineers
Place of meeting: Grand Council Chamber, Federation of British Industries, 21 Tothill Street, London S.W.1

DEVELOPMENT OF FLUID-FUEL REACTORS A. M. Weinberg

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a summary appeared in the *Journal* under 'The *Journal* digest: papers to be read', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card, which is available on request from the Secretary of The Institution

March 1961

M **21** *Tuesday* J. H. WESTCOTT, B.SC.(ENG.), PH.D., J. L. DOUCE, M.SC., PH.D., P. E. W. GRINSTED, PH.D., *and* P. H. HAMMOND, B.SC., will open a discussion on 'Self-adaptive control systems'†

ES **22** *Wednesday* R. CARRUTHERS, B.SC.(ENG.), *and* D. L. SMART, B.SC.TECH. Lecture on 'The engineering aspects of plasma physics'† (Joint Meeting)

April 1961

O **6** *Thursday* W. CASSON *and* H. J. SHEPPARD, B.SC. 'Technical and economic aspects of the supply of reactive power in England and Wales' (paper 3528s) *summary:* see p. 177

MED **7** *Friday* H. S. WOLFF, B.SC., will open a discussion on 'The conversion of biological data into electrical signals'* (at 6 p.m., tea at 5.30 p.m.)

E **10** *Monday* R. E. HAYES, M.SC., PH.D., will open a discussion on 'Applications of electrical phenomena at liquid-helium temperatures'†

ME **11** *Tuesday* D. WOODS. Lecture on 'Precision instruments for coaxial line measurements up to 4 Gc/s'† (supported by paper (3356M) by D. WOODS 'The concept of equivalent source e.m.f. and equivalent available power in signal-generator calibration' *summary:* see p. 177) (Joint Meeting)

S **12** *Wednesday* D. S. ASHWORTH, B.A., *and* P. HAMMOND, M.A. 'The calculation of the magnetic field of rotating machines. Part 2—The field of turbogenerator end-windings' (paper 3489s) *summary:* see p. 177; P. J. LAWRENSON, M.SC. 'The magnetic field of the end-windings of turbogenerators' (paper 3490s) *summary:* see p. 177

ED **12** *Wednesday* J. TOPPING, M.SC., PH.D., will open a discussion on 'Teaching physics to engineers'* (at 6 p.m., tea at 5.30 p.m.)

13 *Thursday* H.R.H. PRINCE PHILIP, DUKE OF EDINBURGH, K.G., P.C., K.T., G.B.E., F.R.S. 7th Graham Clark Lecture. 'Resources, human and material, of the Commonwealth' (Joint Meeting with The Institutions of Civil and Mechanical Engineers at The Institution of Civil Engineers, Great George Street, London S.W.1, at 5.30 p.m.) (see February 1961 *Journal*, p. 127)

I **17** *Monday* The President, SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C., LL.D., B.SC., will open a discussion on 'The education of engineers—all's well?'§

19 *Wednesday* A. N. ARMAN, PH.D., F. J. MIRANDA, DR.-ING., *and* G. R. BISHOP 'Progress in oil-filled cables and their accessories' (paper 3513s) *summary:* see p. 178; P. GAZZANA-PRIAROGGIA, DR.-ING., G. L. PALANDRI, DR.-ING., *and* U. A. PELAGATTI, DR.CHEM. 'The influence of ageing on the characteristics of oil-filled cable dielectric' (paper 3348s) *summary:* November 1960, p. 660

U **20** *Thursday* P. J. H. RATA 'Aluminium in electrical engineering'‡; A. D. SWANSTON, B.SC., *and* B. W. TOWELL 'Diesel railway locomotives'‡; T. E. S. RICKARD, B.SC. 'Automatic programming for hot reversing mills'‡ (Joint Meeting with the London Graduate and Student Section at 6 p.m., tea at 5.30 p.m.)

M **25** *Tuesday* PROF. D. M. MACKAY, B.SC., PH.D. Lecture on 'Simulation of intelligence'†

E **26** *Wednesday* R. H. FRANKLIN, B.SC.(ENG.), *and* J. RHODES, M.B.E., B.SC.(ENG.). Lecture on 'Data transmission'†

O **27** *Thursday* PROF. R. F. WOOLMER, F.F.A.R.C.S., V.R.D. 52nd Kelvin Lecture. 'Medical electronics'‡

S **29** *Saturday* Section visit to Harwell

* No advance information will be available and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available
§ An abstract will be available in advance, but no Press report will be permitted

District Meetings

ARRANGEMENTS for District Meetings in March and April 1961 other than in the area of a local Centre

March 1961

READING (at the George Hotel, King Street, at 7.15 p.m.)
20 *Monday* M. J. L. PULLING, C.B.E., M.A. 'Development of Eurovision'

April 1961

HATFIELD (at Hatfield Technical College at 7 p.m., tea at 6 p.m.)
26 *Wednesday* D. H. McCRACKEN 'Railway electrification in Great Britain'

Automatic level-crossing barriers

THE first automatically operated level-crossing barriers in Britain began operation on the 6th February 1961 at Spath level crossing, near Uttoxeter. This installation replaced the conventional crossing gate, which required operation from an adjacent signal-box.

The new barriers, which are electrically triggered by an approaching train, consist of a single pole fixed on each side of the crossing. The poles cover the left-hand side of the road only and are marked conspicuously in red and white bands. Flashing red lights and two-tone gongs provide additional warning. When raised, the barriers are approximately vertical, and when lowered they are at right-angles to the centre-line of the road.

'Second-train-coming' indicators mounted on separate posts are secured behind each pivot post in such a position as to enable them to be viewed from the far side of the crossing. Mounted above each indicator are the twin flashing red lights, facing in the same direction as the indicators.

The automatic operation of the barriers is effected by means of track circuits and treadles on the tracks. Eight seconds before the train arrives at the crossing, an electric two-tone gong, audible at a distance of up to 300 yards, begins to sound, red lights flash and the boom begins descending to stop oncoming traffic. The gongs stop ringing as soon as the barriers are fully lowered, but the red lights continue to flash. When the train has passed the crossing, the barriers begin to rise and all lights are extinguished.

The barrier will be displayed at the 10th Electrical Engineers Exhibition from the 21st to 25th March 1961 at Earls Court.

OVERSEA ATTENDANCE REGISTER

DURING the period 17th January to 16th February 1961, these members called at the Institution building and signed the Attendance Register of Oversea Members:

AIYER, P. N. S. (Jabalpur, India)
BAKER, A. G. (Lagos, Nigeria)
BROMLEY, H. G. S. (Sierra Leone, W. Africa)
DONALDSON, G. W. (Sydney)
MBIWAN, E. A. (Point Fortin, Trinidad)
OKORO, M. (Lagos, Nigeria)
ROBINSON, G. H. T. (Kaduna, Nigeria)

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 9TH FEBRUARY 1961

	no. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	926	9672	9	7
£2 to <£5	2332	6432	12	4
under £2	30483	16075	2	7
		£48046	7	6

ELECTION OF AN HONORARY MEMBER

AT an Ordinary Meeting of The Institution on the 2nd March 1961, the President announced that the Council had elected the **Rt. Hon. The Lord Nelson of Stafford, Past-President,** to Honorary Membership of The Institution in recognition of his outstanding contribution to the development of electrical science and engineering, and for his many services to The Institution.

39th AWARD OF THE FARADAY MEDAL

AT the Ordinary Meeting of The Institution on the 2nd March 1961, the President announced that the Council had awarded the Faraday Medal to **Dr. Julius A. Stratton,** President of the Massachusetts Institute of Technology, for his notable contributions in the fields of technological education and research in radiocommunication.

APPOINTMENTS AND NOMINATIONS

WIRING REGULATIONS COMMITTEE

ON the nomination of the War Office, the Council have approved the appointment of Mr. R. H. Young, B.SC.(ENG.), ASSOCIATE MEMBER, to succeed Mr. A. A. C. Walker, ASSOCIATE MEMBER, on the above committee.

On the nomination of the electricity supply industry in England and Wales, the Council have approved the appointment of Mr. W. G. H. Chilvers, ASSOCIATE MEMBER, to succeed Mr. H. G. F. Gamble, ASSOCIATE, on the above committee.

COMMITTEE ON REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF AIRCRAFT

The Council have approved the appointment of Mr. S. J. Emerson, M.ENG., MEMBER, to succeed Dr. D. C. Flack, B.SC.(ENG.), MEMBER, on the above committee.

C.I.G.R.É.—BRITISH NATIONAL COMMITTEE

The Council have nominated Mr. F. J. Lane, O.B.E., M.SC., MEMBER, as their representative on the above committee in succession to Sir Harry Railing, D.ENG., HONORARY MEMBER, who wished to discontinue his service.

GLAMORGAN COLLEGE OF TECHNOLOGY, ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING

The Council have nominated Mr. J. F. Wright, MEMBER, as their representative on the above committee.

SUMMER MEETING IN LONDON

29TH MAY TO 2ND JUNE 1961

FOR many years it has been customary for the Institution Summer Meeting to take place in the area of one of the local Centres. This year, however, the meeting is taking place in London, and one of the considerations that influenced the Council in making this departure was the opportunity that a Summer Meeting in London would afford for members to visit the reconstructed Institution building and to see the improvements that have been made.

The programme will begin on Monday evening, 29th May, with a social function at Savoy Place, when full use will be made of the additional accommodation and facilities available. On the Tuesday, Wednesday, Thursday and Friday there will be a variety of interesting technical visits to works and research establishments in the London area, together with excursions of general interest and social functions. The meeting will end on the Friday evening with a supper-dance and cabaret.

Members are asked to note that applications to take part in either the whole or part of the meeting can still be accepted, and if required a further copy of the circular and reply form sent to members in December 1960 may be obtained on application to the Secretary of The Institution.

JOINT MEETING ON 11TH APRIL 1961

MEASUREMENT AND CONTROL, AND ELECTRONICS AND COMMUNICATIONS SECTIONS

THE Joint Meeting of the Measurement and Control Section with the Electronics and Communications Section on the 11th April 1961 will be held in the Faraday Room at Savoy Place. The main entrance of the Institution building should not be used by members and others attending that meeting; instead they are asked to use the entrance at No. 2 Savoy Hill, which is adjacent to the Faraday Room.

CHURCHILL COLLEGE MANAGEMENT COURSE

CHURCHILL COLLEGE, Cambridge, will offer a new management development course from September 1961. The course has been designed to meet requirements formulated by a joint committee of The Institution and the British Institute of Management. This committee saw the need for a course that would be primarily concerned with developing the administrative ability of technically qualified men, that would be long enough to make a substantial impact, and yet would

Announcements to members (continued)

not take men of high calibre from their jobs for lengthy periods at a critical stage in their careers.

This specification is to be met by a sandwich course, so devised that the man's education is continued when he returns to his job. He will be required to carry out field work under university supervision so that he can evaluate the ideas developed in the academic sessions. This approach to education in management has great possibilities; it will involve close contact between the tutorial staff and the firms nominating men and thus will require that collaboration between industry and university which the College is most concerned to foster.

The course will be directed by members of the Engineering Department, University of Cambridge, whose undergraduate industrial management course is now in its second year. The course will last nine months and will include a number of short residential periods in Cambridge, none of which will exceed three weeks.

The field-work assignments will be carried out under the direction of a tutor who will visit each man at regular intervals to discuss progress and to assist him with his difficulties. It is expected that the field work will be carried out during off-duty hours. The outcome of the field work will be a series of individual reports; analysis and discussion of these will form a portion of the work done during the next residential period. Where necessary, measures will be taken by tutors, in collaboration with the firms, to preserve the security of confidential information.

A course which follows this pattern will:

(a) ensure the integration of theory and practice by enabling each man to test at first hand and in his working environment the notions acquired in the residential sessions

(b) encourage the man to approach his immediate problems analytically and so to equip himself for the study and solution of the problems which will face him later in his career

(c) develop management teaching and research in the university.

Entry to the course will be restricted to men who (1) are professionally qualified and (2) have attained a junior management position and are responsible for the work of at least 20 people.

While it is expected that the majority of candidates for the first course will be technologists, members of other professions will be included.

Further information and forms of application may be obtained from F. de P. Hanika, Lector, Churchill College, Cambridge.

1962 WHITWORTH FOUNDATION AWARDS

APPLICATIONS are now invited from candidates for the 1962 Whitworth Foundation Awards. Up to three Whitworth Fellowships of £1000 for each year and up to three Exhibitions of £100 each are offered by the Minister of Education.

British subjects over 25 years of age who hold a university degree in engineering or an equivalent qualification and who have practised as engineers for not less than three years are eligible to compete. The awards are made for theses submitted by selected candidates.

Completed application forms should be sent by the 31st July 1961 to the Secretary, Ministry of Education, (F.E. 111(C)), Curzon Street, London W.1, from whom further information may be obtained.

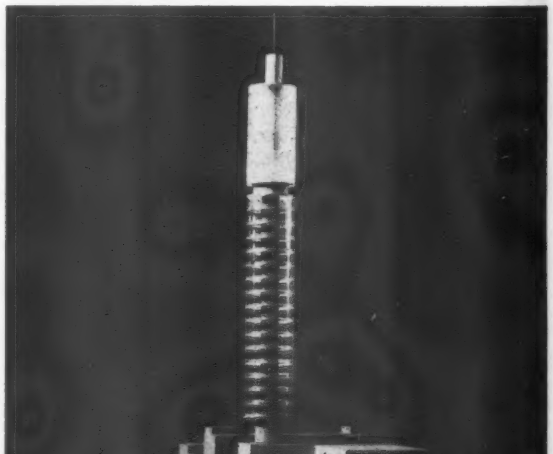
RADIO-LINK TOWER

IN the future, public telephone services and television will depend more and more on microwave radio links, which require a clear line-of-sight path from point to point. High buildings in the path can break the link. The British Post Office is faced with the risk of obstruction from high buildings already constructed and planned in London.

The London focal point for microwave radio links for trunk-telephone traffic and television is the Museum Exchange in Howland Street, London W.1. The Post Office plan to build a 507ft tower at the Museum Exchange by the end of 1963. The new tower will replace the existing radio mast which gives an effective height of only 180ft.

The new tower will be built alongside and in conjunction with a four-storey extension to the exchange (see illustration); the whole will cost about £1·5 million. The tower will not broadcast television programmes direct, but will relay programmes between studios, control centres and transmitters of the broadcasting authorities. There will be room for expansion to meet the foreseeable needs for the next 40 years.

The tower will have a public observation platform at a height of 463ft. There will be six aerial floors and 15 floors for apparatus and offices. The diameter of the tower will be about 50ft; this decision is based on considerations of aerial spacing. In a letter on p. 156, Mr. J. F. Goodger discusses a similar tower at Stuttgart, Germany.



Model of proposed tower and extension at Museum Exchange

LONDON REPORT

ORDINARY MEETING

ELECTRONICS IN SUPPLY

THE Third Hunter Memorial Lecture 'The application of electronics to the electricity supply industry' was delivered by Dr. J. S. Forrest at Savoy Place on the 5th January 1961. The President, Sir Hamish MacLaren, was in the Chair. An article based on the lecture will appear in a forthcoming issue of the *Journal*. The lecturer began by discussing general developments in electronics.

Electronics meant the science of free electrons, the behaviour of electrons in semiconductors and more loosely much of light-current engineering. Large electricity systems required apparatus for metering, protection and testing, and while the existing systems might be satisfactory, improvements were possible with electronic apparatus.

Power production, as measured by increase in load, doubled every ten years, but the production of transistors was doubling every year or two. This difference in rate of change could be seen by comparing a 132 kV Grid tower erected in 1928 and one made today on the one hand, with a radio receiver made in 1928 and one made in 1960 on the other. Grafting a rapidly developing service onto a slowly changing practice meant that existing power systems would continue for some time to appear antiquated against new systems using the latest electronic apparatus.

Thermionic-valve developments had been important, but no step had been so great as the introduction of the transistor and other solid-state devices. Size reduction in components had been accompanied by printed wiring and even printed components. A microminiature triode might be as small as $\frac{1}{2} \times \frac{1}{4} \times \frac{1}{8}$ in. and was much superior to larger valves in robustness and resistance to high temperatures. A silicon junction diode might occupy one-thousandth of the volume of a metal-oxide rectifier of similar performance.

Application to generation

There had been much opposition, not altogether unjustified, to the introduction of valves and radio components in the power-supply industry because of fears of unreliability, but the position was much improved today. Electronics had many applications in power generation. An important one was the use of closed-circuit television for observing fuel combustion, boiler water level, and the slag tap-hole in cyclone boilers, all from the operating engineer's control desk.

The nuisance of dust emission could be mitigated by keeping a continuous record of particle deposition on a transparent screen, the obscuration of which was measured with a photoelectric cell. The screen was blown clean periodically and thus a continuous record was obtained. An electronic device was also used for measuring sulphur dioxide content, and this could be done to a sensitivity of 1 part in 10^8. If necessary, this measurement could be made at various heights above the stack with a captive balloon having an SO_2 recorder that transmitted the result to the ground station.

Computers had an application in connection with high-speed starting-up of generating sets to match the rapid load build-up on a winter morning.

Transmission and distribution

Computers could automatically determine the most economic method of supplying a load increase from a series of interconnected stations, taking account of line losses. Daylight meters and thunderstorm indicators provided useful guidance for the operating engineer.

Reliable communication was essential to the successful operation of a major power system, and this was increasingly being effected by v.h.f. radio. The British supply industry operated 200 fixed and 3000 mobile radio stations.

Accurate data transmission and handling with the use of computers at the generating stations made a completely automatic system feasible.

No electronic system had improved on the conventional watt-hour meter, but summation metering had been made more accurate by electronic means. Metering and protection both depended on current and voltage transformers, which were expensive components that might be replaced by electronic devices, but nothing really satisfactory had been devised. A serious attack on protective systems, with the idea of replacing the present very reliable methods with something entirely new and working electronically, might be rewarding. Electronic equipment could, for example, eliminate moving parts.

Breakdown conditions

Expensive breakdowns could be avoided by the detection of incipient faults, and for this purpose several types of electronic equipment were available. Insulation-resistance measurement, capacitance measurement and discharge detectors had particular applications. Hot joints on overhead lines could be detected by focusing their infra-red radiation on a sensitive thermocouple. A temperature of 80°C could be detected at a distance of 50 metres.

Automatic recording of conditions of a breakdown could be made on a magnetic tape the records on which were automatically wiped out so long as conditions were normal, but retained for subsequent examination if a fault occurred. The location of a fault on an overhead-line system to an accuracy within a few spans in 100 miles of line was possible by means of an ingenious system which measured the r.f. impedance of the circuit and displayed the result on a cathode-ray screen.

Dr. Forrest concluded that the application of electronics in the power-supply industry would lead to greater reliability, fewer menial tasks, a different outlook by operating staff, and an over-all increase in the economy of supply.

Proposing a vote of thanks, Mr. O. W. Humphreys praised the lecturer in his attempt to define electronics and for his elucidation of the fact that there was no distinct branch of engineering which could be called 'electronic engineering'. The vote was carried with acclamation. H. G. T.

EDUCATION DISCUSSION CIRCLE

STUDENTS UNDER EXAMINATION

A LARGE audience listened to Dr. P. F. Soper's remarks when he opened the meeting at Savoy Place on the 12th October 1960, on the subject of laboratory work for the Institution Part III Examination. The Chairman was Dr. K. R. Sturley.

Dr. Soper dealt with the place of laboratory work in the learning process and suggested that the student would obtain maximum benefit only if he had an appreciation of the philosophy underlying the need for such work.

He said that there was much need for a general improvement in the attitude of many students to their experimental work.

He outlined the danger in the use of 'canned' experiments in any advanced course of professional standing, because the work must exercise the thinking powers of the students as well as encourage careful and methodical techniques. The students should learn how to prepare conclusions and should be able to discuss, explain and criticize results. He suggested that the correction and marking of some of the laboratory work left much to be desired.

The lively discussion ranged over a variety of topics from project and drawing-office design work to the difficulties experienced by some physicists in carrying out the course-work. Many views were expressed by teaching staff, by examiners of course-work, and by students themselves, and one can only assume that discussion continued outside for some time after the meeting closed.

The ideal researcher

The title of the discussion on the 28th November 1960 at Savoy Place was 'Training for research'. Dr. F. T. Chapman presided.

Two speakers, Prof. G. H. Rawcliffe and Dr. G. A. V. Sowter, opened the meeting—both knew precisely the type of man they required for research but neither could offer many constructive ideas on how to go about training the individual. The ideal man should be desirous of knowledge and truth and should have ambition and professional pride. He should have ability to think and to read and extract information, have a good knowledge of mathematics and possess an unbiased mind. A first degree was essentially a course of passive learning, while a second degree was more a process of active learning. Stress was laid on the right atmosphere for research. There was much in favour of some industrial experience before entering a research field.

Speakers from the floor made more specific suggestions on training: a number of case studies should be made; project work in the final year of a first degree would give insight into research; a course on sources of information would prove very helpful; every encouragement should be given to students and a spirit of doggedness should be instilled.

In their replies to questions, the two speakers were in great agreement on one point—the research engineer must write good clear English.

But the programme of training for research would inevitably be of a somewhat nebulous nature. Suggestions put forward which would help the co-operation between training establishments and industry included part-time courses, postgraduate work in both the universities and industry on a joint financial basis, consulting work by university staff, and refresher courses for industrial personnel.

The ideal tutor

Prof. C. A. Mace of Birkbeck College, London, opened the crowded meeting at Savoy Place on the 15th December 1960. His subject was 'How to pass examinations, or the psychology of study'.

In a matter of 20 minutes he could deal only briefly with a limited number of aspects, but those that he did touch on were expounded in a masterly manner. He called attention to the lack of provision in the universities of help for students in the best way of studying.

It was presupposed that learning was a biological process and the acquisition of knowledge was the acquisition of a skill. It was therefore necessary to practise that skill, and consequently to talk about a matter was a very necessary process in its understanding. An analogy was drawn between the digestion of knowledge and the digestion of food—and appetite in the form of curiosity was a very desirable quality.

Feedback, in the form of information concerning the results of one's endeavours at acquiring knowledge, was an essential requirement, and great benefit could be derived from play-back. A plea was finally made for an expansion of the tutorial system, and Prof. Mace outlined the qualities of the ideal tutor.

It was to be expected that a most vigorous discussion would follow. Suggested aids to improved study included 'by-passing a difficult section' (although at least one speaker pointed out dangers in this), sleeping on a problem, the formation of a logical sequence in learning, and the revision of laboratory work.

More than one speaker suggested that failures in degree courses were due to the lack of good teachers in the universities, and an interesting side-line then developed on the place of the formal unseen examination.

The Chairman, Mr. J. K. Webb, had, unfortunately, to guillotine the proceedings owing to the lateness of the hour, but it was unanimously agreed that it had been a most stimulating evening. B. F. G.

DISTRICT MEETING AT READING

OPEN FORUM

THE meeting on the 16th January 1961 at the George Hotel, Reading, took the form of an open forum. The Chairman and question-master was Mr. R. R. B. Brown, and the panel consisted of Messrs. T. E. Allibone, R. H. Abell, H. H. Cash, Forbes Jackson, and R. N. Hamilton.

There was an abundance of spontaneous questions from the floor, dealing with such subjects as nuclear energy, power supply, Institution Wiring Regulations, railway electrification, and Post Office telephone engineering.

A lively discussion took place, which the Chairman reluctantly closed at 9.45 p.m. Mr. F. A. Ellis proposed a vote of thanks to the Chairman and the panel for the able way in which they had dealt with a wide range of technical questions.

The meeting was popular, and requests were made for this type of meeting to be repeated. R. G. H.

BULLETIN OF THE SECTIONS

MEASUREMENT AND CONTROL

MYSTERIES OF THE N.P.L. UNVEILED

AT the meeting at Savoy Place on the 10th January 1961, the secrets of the National Physical Laboratory were disclosed to a large and appreciative audience. When most electrical engineers consider the attainment of accuracies within the region of 0·1% as something of an achievement, it was rather refreshing to hear that a number of learned gentlemen were seriously concerned over errors in their measurements of a few parts in a million.

The *pièce de résistance* was a lecture on precision measurement given in two parts by Mr. G. H. Rayner and Mr. A. Felton of the N.P.L. (An electrical engineering review by Messrs. Rayner and Felton appears on p. 141.) The lecture dealt with recent developments and was supported by these four papers on recent work at the N.P.L.: G. H. Rayner and L. H. Ford on 'Improvements in the precision measurement of capacitance' (reviewed on p. 171); S. Harkness and F. J. Wilkins on 'The design of an audio-frequency amplifier for high-precision voltage measurement' (reviewed on p. 168); and J. J. Hill and A. P. Miller on 'Design and performance of high-precision audio-frequency current transformers' and J. J. Hill on 'Techniques for the calibration of standard current transformers up to 20kc/s' (reviewed on p. 169). Mr. C. G. Garton was in the Chair.

The ultimate in capacitance measurement

Mr. Rayner began by describing the present primary standard of mutual inductance, whose value could be precisely computed from linear measurements. He discussed the errors that arose and assessed the total uncertainty in its value as being about 3–4 parts in 10^6. A standard of mutual inductance having been established, resistance was measured in terms of mutual inductance and frequency. Apparently, recent determinations carried out by the N.P.L. and the U.S. Bureau of Standards agreed within 3 parts in 10^6.

Capacitance was measured in terms of mutual inductance and resistance on the Carey Foster bridge, and also in terms of resistance and frequency on the Wien bridge. The two methods agreed within 2 parts in 10^6, but when the uncertainties in the values of mutual inductance and resistance were considered, the absolute unit of capacitance was known to within 20 parts in 10^6.

Mr. Rayner then explained some recent developments in the precise measurement of capacitance which were not referred to in his paper. A new theorem in electrostatics established in recent years by A. M. Thompson and D. G. Lampard in Australia had led to the development of capacitors whose value could be determined from a measurement of length only.

It was anticipated that an accuracy within 1 part in 10^7 might be attained in such determinations, leading to a probable improvement in the determination of the units of capacitance and resistance. However, these new calculable capacitances were rather small in value for convenient use, and a technique of capacitance multiplication by means of high-precision transformer ratios was being studied.

Measurements at audio frequencies

Mr. Felton, taking over from Mr. Rayner, explained the reasons for the development of the devices and techniques described in the last three papers. Although direct current and voltage could be measured with precision in terms of the standard ohm and standard cell by potentiometric methods, a transfer device was necessary for alternating current and voltage measurement. The 100volt electrostatic voltmeter was used for this purpose; it had an optimum sensitivity of a few parts in 10^5 and was accurate to 100kc/s. It was normally used with step-up voltage transformers, shunts and current transformers at power frequencies; but there was a requirement for measurements up to 20kc/s, and the existing accessories were unsuitable for this range.

The new amplifier enabled the range of the electrostatic voltmeter to be extended down to 60mV at 30kc/s, and the new current transformers permitted the measurement of current up to 400amp at the same frequency. Special resistors

had to be developed for these devices and, because of the small size demanded, Evanohm and Karma were used for the resistor material. Many slides were shown of the new devices and accessories.

Above criticism?

It was not surprising that the lecture provoked a lively discussion. Prof. A. M. M. Arnold opened with a witty and humorous discourse on the dangers of criticizing the work of the N.P.L. He commented on the exciting possibilities of the new work on capacitance and examined the design of the new current transformers—a subject on which he was an authority. He expressed the hope that, now that the N.P.L. had demonstrated how to make very good transformers, the manufacturers would adopt these techniques.

Mr. C. G. Mayo expressed the view that it was impossible by law to criticize the N.P.L. and commented on leakage inductance in transformers and on the speed with which the Americans had exploited the work of Thompson and Lampard. Mr. Rayner, however, attributed the American progress to availability of personnel.

A number of other speakers referred to details of the papers and were answered by the authors. During the discussion, Mr. A. Cooper described the new Mayo–Wigan r.m.s. decade voltmeter, which used a novel arrangement of the lamp bridge as the a.c.–d.c. transfer device. Unfortunately, because of the time limit, the Chairman had to terminate the discussion in full swing, thus preventing your reporter, and possibly others, from delivering a carefully rehearsed impromptu speech.

It was a fascinating evening, and we must hope that expositions of the work of the N.P.L. will become a regular event.

F. C. W.

MACHINE-TOOL CONTROL

At the Section meeting on machine-tool control (m.t.c.) at Savoy Place on the 24th January 1961, with Mr. C. G. Garton in the Chair, Dr. E. H. Frost-Smith opened the discussion with a competent and stimulating review of the technical and commercial positions so far reached. A significant point, applying to both aspects, was that at present there was more interest in than demand for m.t.c. techniques.

He suggested that the reason for the poor user response to m.t.c. systems was rooted in the many unknowns that still existed in the economics of their use; the effects on organization, planning and methods; their reliability and operational life; and the need for technical maintenance staff. These were issues that could be resolved only by increased user experience.

Only 10% of m.t.c. projects progressed beyond the prototype stage and, although many control systems were available, very few machine-tool manufacturers were fitting them. Dr. Frost-Smith reviewed a number of the better-known pick-off systems and compared their technical and economic merits. Purely from the point of view of measurement accuracy, it seemed that grating methods based on Dr. L. A. Sayce's work at the National Physical Laboratory had the greatest potential. However, if these were to be exploited to the full, the cost of avoiding ambiguities in the event of temporary breakdown and the provision of high-quality reversible counters would combine to make the systems somewhat expensive.

Lead-screw pick-off methods were cheaper, although not perhaps capable of the same limiting accuracies. He thought that machine tools themselves had received insufficient attention regarding their inclusion in a servo loop. More rigid structures, free from elastic- and thermal-deformation effects, were required, together with the proper use of hydrostatic-lubrication methods at the bearings and lead-screw.

Dependence on commercial success

In spite of lively and interesting exchanges on the technical aspects of m.t.c., the meeting was clearly concerned that no real solution to the problem of putting m.t.c. on the map was apparent. The fact that this was effectively barring progress illustrated once again how the full development of such systems ultimately depended on their success as commercial ventures.

Unfortunately, quick and active appreciation of the potential of new technical developments was not a strong point with British industry, which preferred to wait for America (or Russia) to lead the way. This was a situation we all deplored, and one hoped that the increasing influx of trained engineers into industry would gradually reduce this traditional inertia.

That American industry was fast discovering and exploiting the potential of m.t.c., particularly that of the simpler position-control variety, was pointed out by a number of speakers, as also was the drive and initiative of United States control-equipment manufacturers in offering free fitting to customers' machines on a sale-or-return basis. In this country the extent to which machine-tool manufacturers were themselves adopting or investigating control methods was most unimpressive, and it was felt that they were hardly likely to further the cause with the user industries until they did so.

Needs of the customer

Several speakers made the point that present systems of m.t.c. did not always meet the requirements of the customer and that only the customer could specify what was really required. This was apparently because of the impact of these machines on the particular organizational methods employed by each user and, since this was an independent variable, nobody had succeeded in finding a satisfactory formula for extracting or compiling the requisite information.

One wondered how, in fact, the customer could ever be in a position to furnish an informed specification in the light of such developments until he had gained some real understanding of the situation through his use of m.t.c. on a pilot scale. It was felt that the machine-tool manufacturers could and should take the lead by adopting control techniques themselves, thus acquiring the experience that would enable them to advise.

The meeting was reminded that the field of m.t.c. had arisen out of the aircraft-frame manufacturer's need to machine large fuselage sections from the solid, and that all

developments since then had been concerned with metal cutting. There were, however, other ways of working metals and it was high time that attention was given to these. For example, in hot forging the problem was one of accurately applying and controlling forces rather than of removing metal, and such techniques were widely used.

Rejections and recommendations

No mention was made at the meeting of Prof. Melman's report on the productivity of operations in the machine-tool industry of Western Europe, or of that subsequently published by the Machine Tool Advisory Council under the chairmanship of Sir Stuart Mitchell. The Council rejected Prof. Melman's recommendation for an objective study of the increasing demands of users for special, and usually expensive, features, and categorically stated that the customer knew what he wanted and bought accordingly.

Significantly enough, recent surveys in Germany and Russia have shown very low utilization of machine tools, one reason being that users had inadequate means for assessing their own requirements and played safe by overestimating them. If this is true of conventional forms of machine tools, how much more must it apply to m.t.c. systems.

The main recommendation of the Council was for a major increase in development effort by qualified engineers in the machine-tool industry. One had little doubt that those present at the meeting felt favourably disposed toward this recommendation, but the discussion brought home the fact that, unless user education was pursued energetically at the same time, the present stalemate was likely to remain. This of course neglected the possible effects of competitive dynamite triggered off by our American friends in their traditionally energetic and enthusiastic exploitation of 'anything new'.

C. A. L.

POWER-SYSTEM ANALYSIS

Two extremely interesting papers on the application of digital computers to power-system analysis were presented at Savoy Place on the 18th January 1961. They produced one of the best-attended meetings and a first-class discussion. A *sotto voce* comment was significant and is worth repeating—'The only grey hairs present belong to the Committee members who have any'. It was truly an outing for the younger generation. The papers were 'A general method of digital network analysis particularly suitable for use with low-speed computers' by Mr. M. N. John (see p. 166), and 'Digital computers in power-system analysis' by Dr. P. P. Gupta and Prof. M. W. Humphrey Davies (see p. 165).

Stalemate

Many had anticipated a battle between the supporters of network analysers and digital computers, but it soon became apparent that the enthusiasms of both had been tinged by experience and that, at the present stage of development, neither was pre-eminent and likely to supersede the other. The ideal combination appeared to be pre-digestion—more learnedly, conditioning—on a network analyser followed by rapid digestion on a digital computer. Without the pre-digestion it appeared that on occasions the computer just computed and computed and computed.

The essential difference between the two techniques was that with a network analyser, which was a physical model, once the parameters were set in the solution was left to Mother Nature. With a computer, by and large, Mother Nature was restricted to spectacularly fast and accurate addition and subtraction, and the subtleties of analysis had to be known and exercised by the engineer.

With digital computers two techniques were in use. In the first an initial guess was made at the distribution of voltage required at the junctions ('nodes' to those skilled in the art) to meet the conditions postulated by the planning engineer. An analysis was carried out, and the results were compared with the requirements. If they did not agree (if they did, it would be cause for suspicion), the initial guess was corrected and the whole performance repeated until the results had an acceptable accuracy. The obvious term for this technique was 'reiteration', but it was evident that those skilled in the art preferred 'Gauss–Seidel'.

The alternative was matrix inversion, a routine method of processing which had the unfortunate characteristic that the labour varied at least as the square of the number of nodes. To some extent the choice of method was dictated by the type of computer available, but even a mixture was possible.

A look into the future

The general conclusion was that much remained to be done in developing the techniques for the solution of large networks to meet the constraints placed on them by the operating and planning engineer. This was not surprising when it was realized that, as one speaker pointed out, the first realistic a.c. network analyser in this country and in Europe was commissioned late in 1947 and that the development of advanced system analysis in this country was only 12 years old. A reassessment of the techniques and possibly a completely new approach to the problem were necessary.

This was made evident by one speaker who looked into the future when the control engineer would have available a facility which could advise him of the approach of dangerous running conditions. With a 60-node network, a survey of the system as running, but with each major component removed in turn, would theoretically require more than 120 studies, as stability would have to be checked as well. Assuming that

100 studies would be adequate, then on the basis of four minutes per study—a figure quoted by a previous speaker for a computer with a six-figure cost—a survey of the network would take over three hours. There seemed to be a long way to go before automatic system control could be achieved.

The interest was such and the speakers were so numerous that the meeting ran well beyond normal time. All those present heartily backed the Chairman, Mr. J. E. L. Robinson, when he thanked the authors for providing such an interesting evening. J. R. M.

ELECTRONICS AND COMMUNICATIONS

DISRUPTION OF OXIDE CATHODES

As a title, 'Recent research in thermionics' would appear to appeal to a few specialists in the radio valve and tube field, but Dr. G. H. Metson's lecture at Savoy Place on the 9th January 1961 was surprisingly well attended. The Chairman was Mr. J. A. Ratcliffe.

Dr. Metson explained a mechanism of emission which depended on the presence of active strontium rather than barium. He went on, by means of some interesting experiments well illustrated by colour slides, to expound this theory in more detail.

In all Dr. Metson's work we find he proceeds by steps of propounding the theory, deciding on a critical experiment to prove it and then conducting the experiment, and so it was in this lecture. He showed that the disruption of a normal cathode was only partly due to current and that the principal mechanism was thermal. He also dealt in detail with the honeycomb structure of the matrix.

At the end he showed two films. One film depicted the disruption of a cathode running at low temperature, in which incandescent spots moved over the cathode surface and particles of incandescent material were ejected from the cathode. The second film showed the same phenomenon with a negatively charged electrode at right-angles to the cathode; some incandescent particles were seen to spiral round the negative electrode. Altogether, a most impressive firework display.

Stamina

Mr. A. H. W. Beck opened the discussion and asked about the porosity and density of the matrix structure and how it was held together mechanically. He described another method of measuring the operating resistance. Mr. M. F. Holmes commented on the slow breakdown mechanism of the oxide cathode. Mr. Esterson questioned an assumption made by Dr. Metson that disruption produced loose particles, in effect 'jet-propelled' by oxygen liberated in the dissociation of the matrix. He thought that the anomalies described by the lecturer could be explained by the variation in the charge of the particle owing to emission during its flight.

Mr. D. Rogers had doubts about both the specific loadings quoted in the lecture and the source of energy causing incandescence. Mr. G. D. Monteith and Mr. W. H. Aldous also contributed to the discussion, Mr. Aldous dealing with the running voltage that he was able to use for oxide-cathode rectifiers.

At the beginning of the lecture, Dr. Metson quoted a statement he had heard: 'I don't know how these gentlemen stand these lectures. They must have stamina.' One can only say that the gentlemen did not need stamina, because they found the evening most interesting. A. J. Y.

3000 QUARTS IN A PINT POT

A RAPIDLY growing business like electronics continually throws up new words that seize the imagination, and putting these into perspective is a valuable function of The Institution. This function has already been performed most effectively for such words as transistors and satellites, and Mr. L. J. Ward's lecture on microminiaturization, on the 21st December 1960, was an important contribution along the same lines. The Chairman was Mr. T. B. D. Terroni. Not only was the large audience at Savoy Place given a valuable general survey of the systems and techniques in this new and significant field, but, what was more important, they had clear views on 'the reasons why'—views provocative of much thought and discussion.

Microminiaturization caught the eye because it promised spectacular reduction in the size of components and circuits; certain forms might reach a packing density of 30 million parts/ft^3, which, compared with conventional circuits, meant putting something like 3000 quarts into a pint pot. It had been made possible by the development of solid-state devices, with their inherently small dimensions, low operating voltages and small heat dissipation.

Mr. Ward described both 'packaged' and 'integrated' systems, some already on the market and others in an advanced state of development. In packaged systems, the individual circuit elements were standardized in size and shape, permitting assembly into small modules with simple interconnection arrangements; with integrated circuits, on the other hand, a number of elements were manufactured, together with their interconnections, as an integral unit.

Brink of a new era

Why were we doing all this? One obvious reason was that the number of elements in many electronic systems was increasing rapidly as the systems became more complex; the number of transistors and valves in a typical guided weapon had increased 50-fold in the last few years, and the growth in

the number of such elements in a military aircraft or a warship was now becoming almost asymptotic. Nevertheless, it was important to realize that major reduction in size was not always necessary or even advantageous.

Many took the view that a major object of microminiaturization was increased reliability, but Mr. Ward considered this merely a by-product, although an important one. His own view was that the main pressure for microminiaturization came from the component manufacturers themselves, anxious to develop new techniques and exploit new markets.

However, standardization in the size and shape of the components was in itself a very big step towards increasing ease of automatic or semi-automatic assembly of equipment and could effect a major simplification in the transfer of designs from the research and development stage into manufacture, with the virtual elimination of much of the assembly drafting work and its replacement by tables of instructions which could be fed into a machine. Reliability would come as a by-product because of the lessening of human intervention and the possible reduction in the number of interconnections.

The economics of microminiaturization was hard to prophesy, particularly with integrated circuits, where the combination of a number of components into one element raised serious problems of how to obtain adequate yield. Nevertheless, he felt that we were at the brink of a new era in component and equipment design.

Curtailed freedom

Major points covered in the lively discussion included the extent to which integrated systems might curtail the freedom of the circuit designer, the importance of reliability and of mechanized assembly, and the need for a civil as well as a military market if the cost were to be kept down. A combination of systems by packaging integrated circuits seemed likely, and a special interest in very small components had been shown by the Medical Research Council.

In his reply, Mr. Ward stressed the need for development to proceed rapidly if Britain were to retain a say in the ultimate standards to be adopted and not have these imposed as a result of work abroad.

This lecture was very timely, coming, as Mr. Ward indicated, at the beginning of a new era, which may well require substantial rethinking, not only in the design of components and equipment but in processes of manufacture and, indeed, in the relative roles of the component and equipment designers. Altogether, a stimulating and thought-provoking evening.

L. J. I. N.

TUNNEL DIODES

For ten years the transistor has, figuratively speaking, acted as a magnet attracting exceptionally large numbers to lectures, technical meetings, specialist discussions, etc.

There are now signs that the transistor may have a rival in popularity in the tunnel diode. In Institution circles four times in 1960, twice in London and twice in Scotland, this new device created interest and provoked discussions which were quite up to the standard set by the transistor. True, on three of the occasions mentioned the tunnel diode was supposed to have shared the honours with other new semiconductor devices, but it would appear that on each occasion the tunnel diode excited greatest interest (see for example September 1960 *Journal*, p. 563).

For one thing, the name in itself is intriguing. One of the first questions asked at the well attended specialist discussion at Savoy Place on the 14th November 1960 was the reason for the term 'tunnel'. It was partially answered, but perhaps it would have been well to have delved a little further into the physics of the Esaki effect from which springs the alternative name of Esaki diode.

It also became evident during the discussion that this diode behaved in such a way that one could wish it were not a diode but had three electrodes. Such an arrangement would produce much simpler circuits.

The boiling-water test

Apart from questions of nomenclature, those present collected much valuable information regarding possible applications of this new device from Dr. R. W. A. Scarr and Dr. G. B. B. Chaplin, who opened the discussion. They, by means of diagrams and demonstrations, indicated that, despite its curious name, the device had much to recommend it, both in linear and in non-linear applications.

Outstanding among the demonstrations was undoubtedly Dr. Chaplin's proof that the tunnel diode can work when immersed in boiling water, liquid nitrogen or liquid helium. It can even be transferred quite rapidly from one ambient liquid to another.

Since interested members of The Institution have already observed the device working in a goldfish bowl (London) and in whisky (Scotland), it is clear that it has few, if any, antipathies to liquid.

Use with rectifying diodes

Another point clearly demonstrated was the advantage of building up circuits in which normal rectifying diodes rather than passive components were in association with the tunnel diode. It was clear that the latter, operating as a low-impedance two-state device with high transition speed, was a most interesting addition to the range of tools suitable for memories, logical circuits, etc. There was detectable in the discussion, however, a great interest in the linear behaviour of the tunnel diode. Here there is apparently need for more research and development.

In general, the discussion was brisk and gave the impression that we could look forward to the presentation in the not-too-distant future of several detailed papers dealing with various aspects of the behaviour and utilization of this remarkable device.

Full marks must be given to Dr. E. H. Cooke-Yarborough for his excellent chairmanship, particularly in view of the fact that he was, without warning, led to the Chair a few minutes after the official starting time of the meeting. T. R. S.

ARC-FURNACE ELECTRICITY

THE paper read at Savoy Place on the 8th December 1960 was 'The determination of the electrical characteristics of an arc furnace' by Mr. J. Ravenscroft, which is reviewed on p. 163.

The author described three methods of determining the characteristics and compared these for application to a 10cwt Héroult-type 3-phase arc furnace.

The first method involved direct determination from observations obtained during normal operation of the furnace and in short-circuit conditions; the second resorted to calculation, using an equivalent circuit for the 3-phase arc furnace; and the third and most simple method also employed calculation, treating the furnace as a balanced 3-phase load and using a current-locus diagram to represent the furnace circuit.

The characteristics so obtained for the 10cwt furnace in question showed that this was most efficient, electrically, when operated on the highest voltage tapping, and the simple locus-diagram treatment gave results of sufficient accuracy for all practical purposes.

The discussion was opened by Mr. J. R. Phillips, who said, as a large user of such equipment, that the large arc furnaces being designed presented a problem to supply engineers, because the arc was rather unstable and the power input varied very rapidly, which resulted in a flicker of the voltage on the whole supply system.

Another speaker, referring to the accuracy of measurement, deprecated the use of the ordinary switchboard instruments and pointed out that some misleading curves could be plotted unless the proper instruments were used.

Improvements on both sides

A member of the supply industry expressed the view that the problems associated with large arc furnaces were such that it was of great importance that the fluctuating characteristics should, if possible, be improved by designers. To which observation a furnace designer rejoined that, in order to meet the conditions laid down by supply authorities, it was necessary to resort to expensive correcting devices in the form of buffer reactors and synchronous capacitors; he did, however, appreciate the great importance of endeavouring by suitable means to predict the characteristics of any given unit in the design stage before it was built. Attention was called by another contributor to the effect of the type of electrode regulator used on the average working power-factor of a furnace.

Following the author's reply to the discussion, the Chairman, Mr. J. M. Ferguson, voiced the appreciation of the meeting for his paper. R. H. R.

News from the Centres

NORTH MIDLAND CENTRE

Transistors in line communication

AT a District Meeting at Catterick on the 11th October 1960, Mr. A. A. M. Whitehead presented his joint paper 'The application of transistors to line-communication equipment'. This paper was reviewed in the March 1959 *Journal*, p. 150. In the discussion Mr. Whitehead demonstrated three types of construction used in transistorized equipment, namely printed wiring, engraved circuitry and wrapped connections. He emphasized that each system had its own advantages and limitations and no one system had yet proved sufficiently outstanding to justify its exclusive use.

On the question of relative life it was difficult to obtain reliable and definite figures, but indications of much improvement in the life of transistors over that of valves were being confirmed by such figures as were available. He forecast wide advances in semiconductor techniques, particularly in the regions of power output and frequency rating. He mentioned that there were signs that customers were becoming aware of assemblies, but that maintenance was being concentrated at central points, to which faulty subassemblies could be brought after a replacement had been inserted at the equipment site.

Utilization Group

The session opened for the Utilization Group on the 18th October 1960 at the Leeds and County Conservative Club, when Mr. D. A. Watt presented his paper 'Design of electromagnetic pumps for liquid metals'. Though specialized, the paper gave an interesting account of the methods used for pumping liquid metals, such as sodium, through the cooling system of nuclear reactors.

The second meeting, at Bradford Technical College on the 15th November 1960, was on 'Electricity in the manufacture of hydrogen peroxide' by Messrs. B. E. A. Vigers and R. O. Fletcher. The subject, initially appearing to be remote from electrical engineering, was interesting indeed, and demonstration of the uses of hydrogen peroxide was effective, if staining to the lecturer's hands.

To date, the attendances have been well below the normal average for our meetings, and we look forward to more of our members coming along to support the Group.

Pole-changing induction motor

The paper presented to the Ordinary Meeting on the 1st November 1960 was 'A new form of crane-hoist control using a 3 : 1 pole-changing induction motor'. The meeting was held at the Conservative Club, Leeds, under the chairmanship of Mr. F. W. Fletcher. After a suitable introduction by the Chairman, Dr. O. I. Butler, a member of the Centre, presented his paper, which was followed by a discussion in which many of those present took part.

In proposing a vote of thanks, the Chairman said that Dr. Butler had spoken fully and competently on his subject for 50 minutes without notes and had dealt with a wealth of discussion most adequately.

Annual Dinner

We were very pleased to welcome Mr. O. W. Humphreys, a Vice-President of The Institution, at the Annual Dinner of the Centre at the Queen's Hotel, Leeds, on Friday, 18th November 1960. About 290 members and guests were present to hear Sir Linton Andrews, Editor of *The Yorkshire Post*, propose the toast of The Institution and the Centre in a most entertaining speech in which he stressed the benefits given to the world by electrical engineers.

In replying, Mr. Humphreys referred to the increasing amount of specialization and made a plea for teaching the sources of information rather than detailed knowledge. He thanked Sir Linton for the gracious way in which he had proposed the toast.

The Yorkshire Post

Guests at the Annual Dinner of the North Midland Centre

Back row from left to right: Mr. J. Woodhouse, Mr. J. D. Nicholson, Mr. W. J. A. Painter, Prof. G. W. Carter and Dr. G. N. Patchett. Front row from left to right: Mr. O. W. Humphreys, Mr. F. W. Fletcher and the Ven. E. Treacy

Prof. G. W. Carter extended a warm welcome to the guests in a charming and witty speech. Referring to the guests from the local Press, he expressed the hope that they would continue to be independent for many years so that we would not be altogether dependent on London for our knowledge and information.

Responding to this welcome, the Archdeacon and Vicar of Halifax, the Ven. E. Treacy, interspersed his wit with a warning of the effects of uncontrolled scientific advancement. Appealing for wider views on humanity, he said managers must achieve the right balance between scientific development and humanity.

Thermistors

The 3rd Ordinary Meeting was held on the 6th December 1960 at the Institute of Technology, Bradford.

The Chairman, Mr. F. W. Fletcher, introduced Dr. R. W. A. Scarr and Mr. R. A. Setterington and invited Dr. Scarr to read their paper 'Thermistors, their theory, manufacture and application'. Several persons took part in a most interesting discussion, which was replied to in a complete and competent way by Mr. Setterington.

In thanking the authors for coming such a long way, the Chairman said that they could measure the interest in their paper by the attendance and the quality of the discussion.

H. H.

NORTH STAFFORDSHIRE SUB-CENTRE

Communication and illumination

A COMMUNICATION paper was read by power engineers at the meeting at Stoke on Trent on the 18th November 1960. This was 'Radiocommunication in the power industry' by Mr. E. H. Cox and Mr. R. E. Martin, in which the authors outlined the work that had been done to develop the use of radiocommunication between teams working in the field and the engineer in the control room; it also dealt with some of the problems involved with radio links between mobile stations, and between fixed stations. A short review of the paper appeared in the January 1961 *Journal*, p. 27. The paper was well illustrated by slides and by a film which demonstrated the time saved in restoring supply after a breakdown by using radio as compared with ordinary telephone.

A number of speakers joined the discussion, opened by Mr. R. W. Conway, during which Mr. H. McCartney suggested that, if the Central Electricity Generating Board adopted radio more extensively, the Midlands Electricity Board might regain the use of some of their pilot cables. A vote of thanks to the authors for a very interesting evening was proposed by Mr. W. E. Darby, who recalled that he had worked closely with Mr. Cox when v.h.f. radio had been introduced into North Staffordshire about ten years before. He considered that reliability had been exceptionally good so far as equipment had been concerned, but adequate coverage had presented difficulties in some parts of this rather hilly

area, and modifications designed to improve the coverage were nearly completed.

He said that when using radio it had to be remembered that privacy was often lost. In illustration he recalled an occasion shortly after the equipment had been installed when he had been talking in engineers' language to the control engineer from the car outside his house and a neighbour had called out to say he could hear Mr. Darby's voice on the television.

Gloom or gaiety?

A District Meeting was held at Crewe on the 28th November 1960, when Mr. W. R. Stevens and Mr. H. M. Ferguson read their paper 'A survey of street lighting and its future'. A short account of the paper appeared in the February 1961 *Journal*, p. 100. In view of the general interest in the subject, local-authority members and officers among others had been invited to hear the paper, which had been broadened to include reference to civic lighting, floodlighting and decorative lighting.

Opinions expressed in the discussion were not confined therefore to those of engineers only and gained in interest thereby.

The discussion was opened by Mr. R. Q. Nicholls and Mr. J. P. Oliver. Mr. Nicholls, as a local-government official, noted the subtle references to central control and considered that the Government had already taken over too many local interests. In Crewe they had adopted mercury lighting for the town centre, to agree reasonably with shop-window lighting, and sodium, which he thought was a little cheaper in running cost, for the main bus routes. They also erected special illuminations each year which formed a successful attraction, but it had to be borne in mind that, while decorative and floodlighting could be readily justified in London and other places of historic interest, the problem was quite different in such towns as Crewe where people, having seen the illuminations once, showed little further interest.

In reply, Mr. Stevens said that, while they were not in favour of centralized control of street lighting, the present arrangements spread the cost in a very peculiar way, and many local authorities could do better if given more financial assistance. He said that one town in Scotland had to run a raffle to pay for its street lighting.

The vote of thanks to the authors was proposed by Mr. F. Merrill, who also expressed thanks on behalf of the visitors for the opportunity of hearing such an interesting paper illustrated with so many excellent slides and followed by a very active and illuminating discussion, much of which had been of a very serious nature.

He said that street lighting had its lighter side, however, and this became obvious to anyone who, having designed an installation, tried to erect the columns in the designed positions, only to find that the footpath was already filled with other services and that shop-window blinds or access to premises prevented siting in the correct positions. Most people agreed that good street lighting was desirable, but one resident refused to pay his rates because he could not sleep for the light thrown into his bedroom, while another, who kept a mink farm, asked if a shade could be put on the light as the mink were unable to get their proper rest.

Mixing colours

At the meeting at Stone on the 12th December 1960, a lecture on 'Recent developments in colour television' was given by Mr. I. J. P. James, who first recalled the principles of colour production by mixing suitable quantities of light having the three primary colours of red, blue and green. He then described various methods by which the three colours could be separated, transmitted and mixed again at the receiver to form an acceptable coloured picture, and indicated the limitations and problems still to be solved at each stage from camera to receiver. Slides and demonstrations were freely used in elucidating the various points. An article based on the lecture will appear in a forthcoming issue of the *Journal*.

Although this was a lecture, the author kindly agreed to accept discussion of the subject, and full advantage of this was taken by Mr. A. Asbury and the many other speakers who followed him, so that the discussion lasted as long as the original lecture and contributed much to the interest and enjoyment of the evening.

Mr. R. W. Palmer, proposing a vote of thanks to the lecturer, thought he had been wise in developing the subject from its fundamentals in view of the mixed audience, some members of which had a fair knowledge of the subject while others knew very little of it. He complimented the lecturer on the interest he had aroused, so amply demonstrated by the discussion. He had convinced us that high-quality colour television was possible but awaited further development. All the technical difficulties really came down to a question of cost, and economic solutions would certainly be found. Mr. Palmer thought that the American system, now also adopted by Japan, was not by any means perfect and ours should be improved before being offered to the public. L. G.

News from abroad

MIDDLE EAST GROUP OF PROFESSIONAL ENGINEERS

Oil and water

ON the 24th and 25th November 1960, the Group had another successful meeting in Abadan. The Association of Iranian Engineers in Abadan acted as our hosts.

On the 24th, Mr. C. G. Moore handed over the Chair for the 1960–61 Session to Mr. M. Mohtadi, who needed little introduction to members from Abadan.

Mr. Mohtadi in his opening address spoke on 'The engineering aspects of the distribution of oil in Iran' to some 45 members and guests. He dealt with the engineering aspects of the transport, storage and distribution of petroleum products from the refineries to the consumer in Iran. The address was both interesting and enlightening.

On the 25th, there was a visit to the Khorramshahr Waterworks being constructed for the Khorramshahr Municipality. This waterworks is to supply the population of Khorramshahr with 26000 m^3 of treated river water every 20 hours at a maximum total-dissolved-solids content of 600 parts in 10^6.

D. P. W.